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# OCCURRENCE AND PROPERTIES OF CRYSTALLINE ALUMINA IN SILICATE MELTS*

By Helen Blair Barlett

ABSTRACT

Crystalline habits of the alpha and beta forms of alumina are discussed. A new form, designated as zeta-alumina, which has been found only in melts containing $Li_2O$, is described. Its optical properties and X-ray diffraction pattern are included.

## I. Introduction

It is believed that the literature does not adequately describe the crystallization habits of the alpha and beta forms of alumina so that they may be readily recognized and differentiated. This is especially true in cases where one or more of the identifying characteristics may be obscured by association with other phases of the melt. For this reason it is proposed to describe certain crystallization phenomena that have been observed in connection with the study of various high-alumina melts. In addition, some of the properties of a new high-temperature form of alumina will be given.

## II. Alpha-$Al_2O_3$

In general, it may be said that alpha-$Al_2O_3$, or corundum, shows a tendency to crystallize in one of two different forms, in rhombohedrons or in basal plates. The particular form is probably determined chiefly by the composition of the melt from which crystallization takes place. In high-alumina melts containing little or no silica the corundum occurs in rhombohedrons. These crystals are nearly equidimensional, often rounded rather than well-developed forms, and are characterized by inclusions which may be gaseous or glass.

As the silica content of a series of melts becomes greater the tendency for the alumina to crystallize in thin plates becomes more marked. The plates vary according to the conditions of heating and cooling. In rapidly cooled melts they may be microscopic in size, while in large batches which have been allowed to cool rather slowly they may measure an inch or more across. But in practically all cases it has been observed that these plates are not single crystals, but are composed of thin lamellae which are made up by the parallel grouping of basal plates truncated by a hexagonal prism and elongated parallel to two opposite faces of the prism. This produces very fine striations on the smooth surface, which are more or less regularly interrupted by the completion of the prism form.

Intercalated between the lamellae is glass, which may, because of its extremely intimate association with the corundum, obscure the optical

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (White Wares Division).

properties of that crystal. When this glass is dissolved out with acid, however, the character of the corundum becomes apparent, and it is readily identified. The combination of these basal plates and lamellae may be such as to produce long thin lathes, or, if the lamellae are thicker or more numerous, slender rods with nearly equidimensional cross-section.

When viewed in cross-section, that is, in sections perpendicular to the plane of the plates, the corundum appears to be in lathes with parallel extinction, which may be confused with mullite unless care is taken in measuring the refractive index. This determination may often be troublesome on account of the associated glass. The optic sign also serves to differentiate it from mullite, but on smaller crystals this also may be difficult to ascertain.

The broad, thin platy structure has been observed to be especially well developed in the composition, 30% orthoclase and 70% $Al_2O_3$, which was fused in an electric arc pot furnace. In striking contrast to this structure was that observed in a melt of the same composition made up in the same furnace, but in which the potash was introduced as $K_2CO_3$ and the silica and part of the alumina as Georgia kaolin. Here the corundum had crystallized in skeletal rhombohedrons. The edges of the rhombohedral form were marked by slender rods which appeared much like those composed of basal plates and intercalated glass. Unlike the latter, however, they extinguished at a wide angle with their direction of elongation when examined between crossed nicols. This manner of crystallizing is unusual, however; the lamellar structure is ordinarily found in the presence of silica regardless of the manner in which the melt was made, the variation being largely in the extension of the plates rather than in the crystal form.

## III. Beta-$Al_2O_3$

The highest yield of what is known as beta-$Al_2O_3$ was obtained by fusing alumina with 10% alkali ($Na_2O$ or $K_2O$) in an electric arc furnace. About 75% of the product was beta-alumina, the rest being essentially alpha. Lesser amounts of alkali yielded less beta-$Al_2O_3$; but none whatever has been observed in melts containing $Li_2O$. While these melts appeared to be composed of platy crystals in the hand specimens, petrographically there was no evidence of a prominent cleavage, either basal or otherwise. This is apparently contrary to the experience of other investigators.

## IV. Zeta-$Al_2O_3$

A new form of alumina, which is designated as zeta-$Al_2O_3$, is readily distinguished from the alpha and beta varieties, and so far as the author is aware has not been described in the literature. Zeta-$Al_2O_3$ crystallizes

from melts containing $Li_2O$, the amount of lithia required to produce it increasing with the silica content of the system. When no silica is present, zeta-alumina may be obtained with as low as 1 or 2% $Li_2O$, with the maximum yield at about 5% when the fusion is made in an electric arc. In a melt of alumina containing 5% lithia only a small percentage of alpha-corundum and of a lithium aluminate is formed in addition to zeta-$Al_2O_3$.

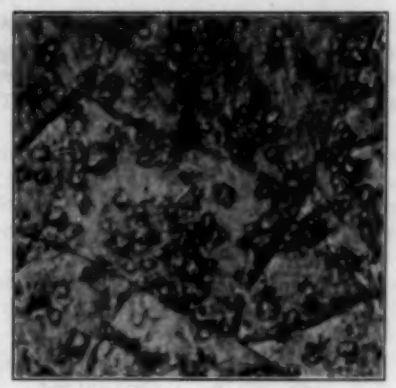

FIG. 1.—Photomicrograph of zeta-alumina octahedrons embedded in lithium aluminate (× 360).

This new crystal occurs in octahedrons, and hence is isotropic. The octahedrons may be very well-developed individuals, especially when crystallizing from a silicate melt (as seen in Fig. 1), a photomicrograph showing them embedded in a lithium aluminate; or they may crystallize in parallel groups where only part of the faces are developed. The refractive index of this crystal is 1.736, the dispersion strong. As would be expected from the index, the specific gravity, 3.6, is intermediate between that of the alpha and the beta forms, for which the values are 4.0 and 3.31, respectively.

To determine the composition of this new crystal phase which was discovered in an investigation of the $Li_2O$–$Al_2O_3$–$SiO_2$ system, some of the crystals were purified and then submitted to Earle R. Caley, Princeton University, for analysis, with the following result:

| | |
|---|---|
| $Li_2O$ | 0.35 |
| $Al_2O_3$ | 99.70 |

The small percentage of lithia was doubtless present as impurity, either as lithium aluminate which may not have been removed in the purification process or in the cavities of crystals which had not been ground finely enough to break them open.

As a further check on the nature of this crystal its X-ray diffraction pattern was obtained by the Debye-Scherrer-Hull method. The data corresponding to this pattern are given in Table I. The length of the unit cube as calculated from the positions of the lines on the X-ray film is 7.90 Å. While the fundamental structure has not been worked out as yet, it seems that it is probably similar to that of spinel, face-centered cubic.

The relation of zeta-$Al_2O_3$ to corundum is not clear as yet. Pure crys-

tals remain unaltered when subjected to a temperature of 1600°C for several hours. Fusing it, however, results in an inversion, apparently over a considerable period, to the alpha form. The presence of silica

TABLE I

ZETA ALUMINA

Wave-length = 0.710 Å.
Radius = 20.2832 cm.

| Line No. | Intensity I | Reflection angle | Planar spacing $\frac{d}{n}$ | Crystal face | $a_0$ in Å |
|---|---|---|---|---|---|
| 1 | 5 | 7° 17′ 11″ | 2.799 | 110(2) | 7.9169 |
| 2 | 9 | 8° 33′ 58″ | 2.383 | 113 | 7.9046 |
| 3 | 1 | 8° 57′ 42″ | 2.279 | 111(2) | 7.8945 |
| 4 | 9 | 10° 21′ 5″ | 1.975 | 100(4) | 7.9027 |
| 5 | 4 | 12° 44′ 18″ | 1.610 | 211(2) | 7.8873 |
| 6 | 9 | 13° 30′ 4″ | 1.520 | 111(3) | 7.9011 |
| 7 | 10 | 14° 43′ 17″ | 1.397 | 110(4) | 7.9025 |
| 8 | 2 | 16° 30′ 3″ | 1.250 | 130(2) | 7.9049 |
| 9 | 4 | 17° 7′ 10″ | 1.206 | 533 | 7.9082 |
| 10 | 3 | 18° 8′ 1″ | 1.140 | 111(4) | 7.9024 |
| 11 | 3 | 19° 36′ 20″ | 1.058 | 321(2) | 7.9172 |
| 12 | 5 | 20° 10′ 33″ | 1.029 | 731 | 7.9060 |
| 13 | 3 | 21° 3′ 6″ | 0.9883 | 100(8) | 7.9062 |
| 14 | 3 | 22° 53′ 36″ | 0.9125 | 751 | 7.9030 |
| 15 | 3 | 23° 41′ 49″ | 0.8833 | 210(4) | 7.9005 |
| 16 | 3 | 25° 22′ 19″ | 0.8285 | 931 | 7.9032 |
| 17 | 4 | 26° 6′ 44″ | 0.8066 | 211(4) | 7.9028 |
| 18 | ? | 27° 12′ 55″ | 0.7762 | 431(2) | 7.9161 |
| 19 | 2 | 27° 41′ 3″ | 0.7641 | 773 | 7.9039 |
| 20 | 1 | 30° 31′ 58″ | 0.6988 | 110(8) | 7.9057 |
| 21 | ? | 32° 25′ 57″ | 0.6619 | 965 | 7.8879 |
| 22 | 1 | 34° 37′ 18″ | 0.6248 | 310(4) | 7.9035 |
| 23 | 1 | 35° 57′ 23″ | 0.6046 | 331(3) | 7.9061 |

Mean value $a_0$ = 7.9039 Å

accelerates this change and causes it to occur at lower temperatures. Further work is yet to be done on this phase of the problem as well as on the study of other physical and chemical properties of the crystal.

## V. Summary

It has been shown that the habit of alpha-$Al_2O_3$ in silicate melts is variable, that a platy structure is common to it and is more pronounced than that of beta-$Al_2O_3$, and that its optical properties may be obscured by intimate association with glass.

Zeta-$Al_2O_3$ crystallizes from lithia melts in octahedrons. Its refractive index is 1.736, specific gravity 3.6, and the size of its unit cube, which is probably face centered, is 7.90 Å.

**Acknowledgment** The author wishes to acknowledge with gratitude the counsel and assistance of William J. McCaughey of Ohio State University under whose direction the study of zeta-$Al_2O_3$ was made.

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# THE TEMPERATURE COEFFICIENT OF VISCOSITY AND ITS RELATION TO SOME OTHER PROPERTIES OF LIQUIDS AND GLASSES*

By F. W. Preston

ABSTRACT

A possible connection between the temperature coefficient of viscosity (not the viscosity itself), the latent heat of fusion or some similar work-function, and the absorption spectrum of liquids and glasses is discussed. The three things seem to be connected in a fairly clear and simple manner.

It is shown, for instance, that from viscosity data alone it is possible to predict the position of the ultra-violet absorption band in glasses, and the black color of pitch. Also, that at high temperatures the ultra-violet absorption band invades the visible spectrum and migrates down into the infra-red, and that at room temperature the viscosity of typical soda-lime-silica glasses is of the order $10^{70}$ poises. A meaning is attached to the term "viscosity" at temperatures at which it can not be measured mechanically, and a means of tracing it optically down to absolute zero is suggested.

## I. The Relation between Viscosity and Temperature

Data on the viscosity of some glasses from furnace temperatures to annealing temperatures are fairly complete, but are not as yet represented by satisfactory formulas.

### (1) History of Studies of Viscosity-Temperature Relations

S. E. Sheppard[1] has dealt with the connection between viscosity and temperature of liquids. The most significant work is that of de Guzman[2] in 1913. Dunn[3] worked along the same line as did Sheppard.

In the meantime Andrade had found the same relationship on a purely empirical basis,[4] and D. E. Sharp[5] had discovered the empirical Porter relationship[6] from which the Andrade formula may be deduced.

Fulcher,[7] working on the viscosity of glasses, would also have reached the same conclusion if the data had then been more complete. He adopted a somewhat arbitrary variant of the logical formula to express his findings, and Andrade in a second communication to *Nature*[8] adopted the same formula, though no doubt unaware of Fulcher's work.

Inasmuch as these concepts are more or less new in the field of glass technology, they are presented substantially as they were written before

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Glass Division). Received March 3, 1932.

[1] *Nature*, **125**, 582 (1930); *Jour. Rheol.*, **1**, 349 (1930).
[2] de Guzman, *Anales soc. espan. fis. quim.*, **11**, 353 (1913).
[3] J. S. Dunn, *Trans. Faraday Soc.*, **22**, 401 (1926).
[4] Andrade, *Nature*, March 1, 1930.
[5] Private communication.
[6] A. W. Porter, *Phil. Mag.*, 1912; see Andrade, *loc. cit.*
[7] Fulcher, *Jour. Amer. Ceram. Soc.*, **8**, [6], 339 (1925).
[8] *Nature*, April 12, 1930.

Dr. Sullivan called attention to Sheppard's work, and thereby to the earlier literature generally.

That part of this paper which relates to the latent heat concept has apparently been completely anticipated, as far as ordinary liquids are concerned, by de Guzman.[9] Sheppard identifies his "work-function" somewhat differently.

NOTE: That part of this paper which deals with the optical properties of the glass or pitch is a logical extension of the subject, which has apparently not been made by earlier writers. It may be regarded as derived either from the logical (thermodynamical) treatment or from the empirical formula of Andrade and Sharp by the logic of quantum requirements. This treatment of the optical properties has nothing in common with that of Schulz, which is mentioned later.

## II. Latent Heat Concept

The fundamental idea underlying the present treatment is that the fluidity of a liquid (*i.e.*, the reciprocal of its viscosity) is strictly analogous to its vapor pressure. The vapor pressure measures the willingness of the liquid to renounce the liquid state and become a gas. The fluidity measures its willingness to renounce the solid state and become a good liquid.

The relation between vapor pressure and temperature has been given by Boltzmann as follows:

$$\frac{d(\log_e p)}{dT} = \frac{l}{RT^2}$$

Where $p$ = vapor pressure
$T$ = absolute temperature
$R$ = "gas constant" occurring in the formula $pv = RT$
$l$ = latent heat of *evaporation* of quantity of gas, $v$ ($v$ is generally taken as a gram-molecule volume, so $l$ and $R$ also refer to a gram-molecule)

By analogy

$$\frac{d(\log_e \varphi)}{dT} = \frac{L}{RT^2}$$

Where $\varphi$ = fluidity
$L$ = latent heat of *fusion*

### (1) Fluidity and Vapor Pressure Analogous Terms

The belief that the fluidity is analogous to vapor pressure arises somewhat as follows:

The viscosity of a liquid is commonly ascribed to a momentary "sticking together" of its molecules. Thus clean, round silica sand runs comparatively freely in the cold state because the grains do not stick; at a high temperature this freedom is lost, the grains welding to one another, and the mass becomes viscous. The viscosity so attained can not be undone, but in the case of fused silica, it is supposed that the molecules *can* come apart and that they stick and part continually.

[9] The author has not actually seen de Guzman's work, but quotes Sheppard.

The process of sticking together is one of polymerization. Polymerization, carried far enough, produces a crystal or solid. A solid is merely a very high polymer. The heat of fusion or of solidification is thus essentially the same thing as the energy set free by the polymerization process.

NOTE: It may be shown in a theoretically simplified way that the energy released (per gram) by the reaction $SiO_2 + SiO_2 = Si_2O_4$ is one-half that released by the reaction $n(SiO_2) \longrightarrow Si_nO_{2n}$ ($n$ being large) or, more generally, that the heat of polymerization bears a definite relation to the heat of crystallization (in Andrade's words, each is a "heat of juxtaposition").

The stickiness produced by the (momentary) adhesion is a measure of the viscosity. At any temperature the reaction goes both ways $(SiO_2)_n + (SiO_2)_n \rightleftharpoons (SiO_2)_{2n} + L$, where $L$ is the latent heat set free by the polymerization.

Such a reaction is one of mobile equilibrium, and will presumably follow the same temperature variation as the constant of chemical equilibrium or the vapor pressure.

Therefore
$$-\frac{d(\log_e \eta)}{dT} = \frac{L}{RT^2} \qquad (1)$$

Where $\eta$ = viscosity in *any* units (English, French, etc.)[10]
$T$ = absolute temperature
$R$ = gas constant (occurring in the expression $pv = RT$)
$L$ = latent heat of fusion of the substance

$L$ and $R$ must be in consistent units, so that if $R$ is in ergs per °C, $T$ must be in Kelvin degrees and $L$ is in ergs per gram-molecule. In tables of constants, $L$ is often given in gram-calories per gram or in joules per gram. The conversion to ergs per gram must be made.

The formula may be more conveniently written

$$\frac{d(\log_e \eta)}{d(1/T)} = \frac{L}{R} \qquad (2)$$

For a given substance $L/R$ is a constant (subject to the restrictions discussed later), and therefore log viscosity plotted against the reciprocal of the absolute temperature gives a straight line.

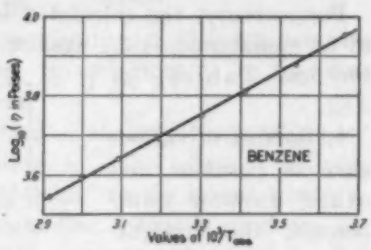


FIG. 1.—*Benzene:* Log viscosity plotted against reciprocal of Kelvin temperature. The line seems to be perfectly straight. Viscosity data from Kaye and Laby.

This is found to be true in many cases. The straight-line relationship holds for benzene and most carbon compounds. It holds apparently for mercury and for the technical soda-lime-silica glasses from the strain point to the softening point, but not above this. The numerical value of $L$, as deduced from the viscosity temperature relation, may be checked for comparison with the observed value.

[10] See Appendix II, p. 377.

For the purposes of the calculation, it may be better to express $L$ in gram-calories per gram instead of ergs per gram-molecule. Introducing $J$ (Joules' equivalent) and $M$ (the molecular weight), and also using ordinary logarithms, the formula becomes

$$L \text{ (gram-calories/gram)} = \frac{R \log_e 10}{JM} \frac{d(\log_{10} \eta)}{d(1/T)} \tag{3}$$

$$= \frac{4.6}{M} \frac{d(\log_{10} \eta)}{d(1/T)} \tag{3a}$$

The molecular weight is not always known. In the case of glasses not even the chemical formula is known, but in the case of the more ordinary liquids the chemical formula is known and therefore the "formula weight." The molecular weight is $n$ times this where $n$ is the effective polymerization, *e.g.*, the apparent average number of formula weights in a molecule. Most liquids are believed to be more or less "associated." Benzene is believed to be sensibly free from it.

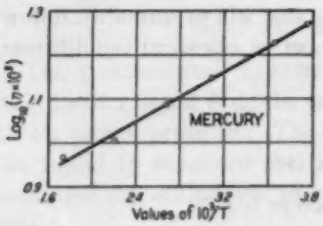


FIG. 2.—*Mercury:* Log $\eta$ plotted against $1/T$; again the line seems to be straight; viscosity data from Kaye and Laby.

The value of $L$, calculated as above for benzene, comes out at 31.4 gram-calories per gram, as against the observed value 30.6.

For mercury, the calculated latent heat of fusion, assuming mercury to be monatomic, is 3.1 against the observed value (in the Smithsonian Physical Tables) of 2.82.

In the case of various alcohols, paraffins, and other carbon compounds, the straight-line relationship seems to hold well enough, but the value of the latent heat generally comes out too high if the molecular weight is assumed to be the same as the formula weight. If, however, ethyl alcohol, for instance, is polymerized until its average molecule is $(C_2H_6O)_n$ instead of $C_2H_6O$, and the observed value of the latent heat of fusion is used, the value of $n$ may then be calculated.

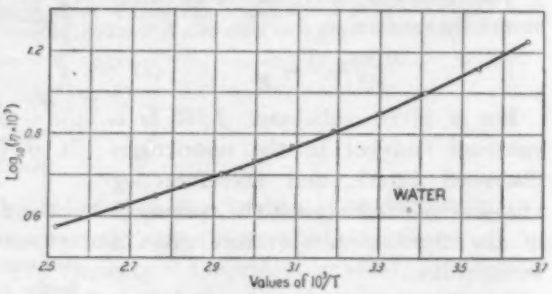


FIG. 3.—*Water:* Log $\eta$ against $1/T$. The curve is not straight. The effective polymerization is greater at low temperatures. At high temperatures there seems to be some evidence that $H_4O_2$ is the limiting degree of dissociation.

In the case of water, the straight-line relationship does not hold over the range 0 to 150°. (See Fig. 3.) At 100°C the slope of the curve corresponds to $(H_2O)_2$ and at 0°C to about $(H_2O)_{3.5}$.

**(2) Application to Glasses** For several years the author has tried to fit a formula of the above type to the glasses on whose viscosities so much work has been done, but the results would not fit, any more than they will fit for water. D. E. Sharp recently called attention to a relation he found among the viscosities of Lillie's glasses,[11] from which the Andrade formula could be deduced,[12] *viz.*:

$$\eta = Ae^{b/T}$$

Where $A$ and $b$ = constants.

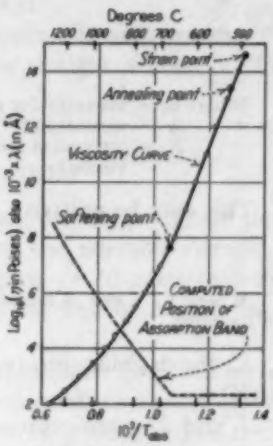


FIG. 4.—Lillie's glass No. 1: $SiO_2$ 69.73, $Na_2O$ 20.96, CaO 9.05, $R_2O_3$ 0.18; total 99.92. Between the softening point and the strain point the curve seems perfectly straight.

The relation noticed by Sharp for Lillie's glasses had previously been found by A. W. Porter for various liquids other than glasses.

From the work of Fulcher[13] and from the writer's contemporaneous unpublished investigations it was clear that the formula did not apply to glasses, but in those days Lillie's results were not available; the only comparatively high-temperature measurements were those of the earlier investigators.[14] It therefore seemed advisable to reëxamine the subject.

The plot of log viscosity against reciprocal of absolute temperature for Lillie's No. 1 glass is accordingly given in Fig. 4.

It will be seen that from the "softening point" to the lowest temperatures reached the curve is in fact a straight line. This is precisely the range of temperatures in which Lillie's work extends with accuracy that of the earlier investigators. Above the softening or setting point (above 650°C or thereabouts) the straight-line relationship no longer holds. It does hold, however, through the annealing range and much above it. Some further consequences will be deduced a little later, but for the moment attention is drawn to Twyman's original work on annealing.[15]

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[11] H. R. Lillie, *Jour. Amer. Ceram. Soc.*, **14** [7], 502 (1931).
[12] E. N. da C. Andrade, *Nature*, March 1, 1930.
[13] G. S. Fulcher, "Analysis of Recent Measurements of Glass," *Jour. Amer. Ceram. Soc.*, **8** [6], 339–55 (1925).
[14] Stott had given some data at low temperatures but not in a very convenient form.
[15] *Jour. Soc. Glass Tech.*, **1**, 62 (1917).

**(3) Twyman Viscosity Formula**

Twyman's formula for the viscosity over a short range of temperatures of interest to the annealer is tantamount to

$$\eta = \eta_0 2^{\frac{T-T_0}{-K}} \tag{4}$$

Where $\eta_0$ = viscosity (or resistance to annealing) at some arbitrary temperature, $T_0$
$\eta$ = viscosity at $T$ degrees
$K$ = interval of temperature through which glass must be heated to halve the viscosity

This may be written

$$\eta = \eta_0 e^{\frac{T-T_0}{-K_2}}$$

Where $K_2$ = rise of temperature required to reduce viscosity to $1/e$ (*i.e.*, to 0.368) of its value.

$K$, the doubling-interval, was found by Twyman to be normally around 10°C.

$T$ and $T_0$ were expressed in °C also, but they could equally well be in Kelvin degrees, for the value of $T-T_0$ is the same in either system. The Kelvin scale may be used since it is more logical. Then $T$ and $T_0$ are each several hundred degrees, while their difference, $T-T_0$, is small over the range of temperatures of interest to Twyman, and therefore it is permissible to write

$$K_2 = T \cdot T_0 / K_3$$

Where, if $K_2$ is an absolutely fixed constant, $K_3$ is all but constant.

Then $\eta = \eta_0 e^{\frac{-K_3(T-T_0)}{T \cdot T_0}} = \eta_0 e^{-K_3\left(\frac{1}{T_0} - \frac{1}{T}\right)} = \left(\eta_0 e^{\frac{-K_3}{T_0}}\right) e^{\frac{K_3}{T}}$ or $\eta = K_4 e^{K_3/T}$ (5)

This is the same as the Andrade formula. Taking now the author's differential equation

$$\frac{d\ (\log_e \eta)}{d(1/T)} = \frac{L}{R} \tag{6}$$

and integrating it, the following formula is obtained:

$$\eta = \eta_0 e^{\frac{-L}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

This is really the same as the Andrade formula, except that one of the arbitrary constants is replaced by a non-arbitrary one.

The latent heat, $L$, as shown, is the latent heat in ergs per gram-molecule when the formula is expressed throughout in absolute units. This value of $L$ may be calculated from the slope of the curve shown here, but as the molecular weight is not known, the latent heat per gram can not be calculated. And since the latent heat of crystallization of the glass is not known, the molecular weight can not be calculated.

$L$, in fact, as it appears in the equation is $M \times u$, where $M$ is the effective molecular weight and $u$ is the latent heat in ergs per gram. If one is known, the other may be calculated.

Something may be done, however, with the product, $L$, as it stands.

The value of $L/R = (d \log_e \eta/d(1/T))$ over the straight portion of the curve is 61,000.

If $R = 8.3 \times 10^7$ ergs per °C
$J = 4.18 \times 10^7$ ergs/gram-calorie
$L/J$ = latent heat in gram-calories/gram-molecule = 121,000

The latent heat of crystallization of Lillie's glass (or for any glass) per gram is not known. Sosman[16] gives the heat of the reaction vitreous-silica ⟶ quartz at 1710°C as 210 joules per gram or 50 gram-calories per gram. At 500°C the reaction heat would be less by about one-fourth (*i.e.*, 40 gram-calories per gram).

Lillie's glass is about 70% silica, and if the latent heat involved were that of silica alone, or if the other theoretical (potential) crystals,[17] devitrite and sodium disilicate, had comparable heats of crystallization then the effective molecular weight would be 121,000/40, or 3000. This seems reasonable and at any rate of the right order, for the formula weight of devitrite ($Na_2O$ 3CaO $6SiO_2$) is itself 592 and Lillie's glass, if crystallized, would consist very largely of this.

This, however, is not the most interesting point. Another deduction may be drawn and tested.

Divide $L$, the latent heat of energy per gram-molecule, by $N$, the number of molecules in a gram-molecule, or $6.06 \times 10^{23}$, giving the latent energy of solidification, per molecule, $\epsilon$.

Applying the quantum relation, $\epsilon = h\nu$, where $h$ is Planck's constant $6.55 \times 10^{-27}$ erg-seconds, $\nu$ may be calculated. $\nu$ is some frequency of importance to the process of polymerization, or it may dominate the course of fluidity with temperature.

Further $\nu = c/\lambda$
Where $c$ = velocity of light in Å./sec. = $3 \times 10^{18}$
$\lambda$ = the critical or important wave-length in Å
Then $L = Nh\nu = Nhc/\lambda$
Or alternatively, $\dfrac{L}{R} = \dfrac{Nhc}{R\lambda} = \dfrac{hc}{K\lambda}$
Where $K$ = the Boltzmann constant = $R/N$
Finally $\lambda = \dfrac{hc}{K} \div \dfrac{L}{R} = \dfrac{hc}{K} \div \dfrac{d(\log_e \eta)}{d(1/T)}$

$$= \frac{hc \log_{10} e}{K} \div \frac{d(\log_{10} \eta)}{d(1/T)} \qquad (7)$$

$$= 6.3 \times 10^7 \div d(\log_{10}\eta)/d(1/T) \qquad (7a)$$

= (6.3 × $10^7$ divided by the slope of the curve). Over the straight part of the curve $d(\log_{10}\eta)/d(1/T) = 26.5 \times 10^3$ so that $\lambda = 2370$ Å.

[16] International Critical Tables, Vol. 5, p. 105.
[17] That is, "normative minerals."

This will be recognized at once as the position of the absorption band in the ultra-violet, which all soda-lime-silica glasses show. Fritz-Schmidt, Gehlhoff, and Thomas give the limit of transmission of the sodium silicates (82% silica) as 2200 Å. Addition of calcium brings this to a slightly greater wave-length.

Judged by the viscosity curve, the absorption band (presumably its center) stays at this wave-length from room temperature to 600°C or thereabout, but at higher temperatures the band encroaches on the visible, as shown by the shape of the viscosity-temperature curve.

NOTE: In order to check the relationship with some other investigators' work, the glass, "St 59" is cited as reported by Stott, Irvine, and Turner, in *Proc. Roy. Soc.*, **A108,** 159 (1925), Fig. 4.

This glass is quite different in composition from Lillie's, and more complicated. It is given as $SiO_2$ 66.66, $Al_2O_3$ 4.33, CaO 6.30, MgO 1.08, $Na_2O$ 15.50, and $K_2O$ 5.58, with some iron and boric oxide.

Its importance lies in the viscosity measurements being carried to very low temperatures and very high viscosities (420°C, $\log_{10}\eta = 16.6$), which is further than Lillie's deductions. On the other hand the highest temperatures graphed are only 615°C or thereabout.

A plot of $\log\eta$ against $1/T$ gives a good straight line, except at the lowest temperature of all (420°C) where there is likely to be some difficulty in measuring it satisfactorily.

The absorption band calculated from the straight line is at 2630 Å, which is entirely plausible.

H. Schulz, *Keram. Rund.*, **33,** 395 (1925), has given a formula for the connection between viscosity and absorption bands. This formula is not of quite the same form as the one used in this paper, and is derived from different premises. It is not quite so tractable a formula, but it is more completely quantized and merits attention. The author was not able to follow its derivation completely; it starts from the Einstein formula for the energy of a gram-molecule, and the frequency used by Einstein is intended to be that of the "residual rays" in the far infra-red. Schulz applies it, however, to the ultra-violet absorption band.

His formula is

$$\eta^2 = \frac{A}{\nu}\left(e^{\frac{\beta\nu}{T}} - 1\right) \qquad (1)$$

Here $A$ = a constant of some sort
$\nu$ = characteristic frequency of the substance
$\beta = h/K$

At high temperatures or high frequencies, $e^{\beta\nu/T} - 1$ reduces for all practical purposes to $e^{\beta\nu/T}$, so that Schulz's formula becomes

$$\eta = A^{1/2}\,\nu^{-1/2}\,e^{\frac{\beta\nu}{2T}} \qquad (2)$$

Hence
$$\log_e\eta = \tfrac{1}{2}\log_e A - \tfrac{1}{2}\log_e\nu + \frac{\beta\nu}{2T}$$

and
$$\frac{d(\log_e\eta)}{d(1/T)} = -\frac{1}{2}\frac{d(\log_e\nu)}{d(1/T)} + \frac{\beta\nu}{2}$$

or
$$\frac{\beta\nu}{2} = \frac{d(\log_e\eta)}{d(1/T)} + \frac{1}{2}\frac{d(\log_e\nu)}{d(1/T)} \qquad (3)$$

as compared with the author's formula $\beta\nu = \dfrac{d(\log_e \eta)}{d(1/T)}$ = slope of plotted curve (4)

Assume first that $\nu$ is a constant independent of temperature, so that the absorption band stays in one place; then the second term of the right-hand side of equation (3) vanishes, and the value of $\nu$ as deduced by Schulz is twice as great as that deduced by the writer. Thus the absorption band of Lillie's glass should be at $\lambda = 1185$ Å, instead of 2370°, when the glass is near the annealing point. This seems improbable.

Assume next that $\nu$ is not constant, but that the band migrates to longer wave-lengths with increasing temperature. Then $d\nu/dT$ is negative and $d\nu/d(1/T)$ or $d(\log \nu)/d(1/T)$ is positive.

Thus the second term of the right-hand side of equation (3) is positive, so that the whole right-hand side is greater than if this term vanishes. This puts the band still farther into the ultra-violet. Thus, Schulz's formula, if valid at all, is not valid for the familiarly known absorption band.

The following results are deduced:

| Temp., °K | Temp., °C | Temp., °F | Absorption band at |
|---|---|---|---|
| | 400–600 | (700–1100) | 2370 ultra-violet |
| 1000 | 730 | (1300) | 3500 extreme violet |
| 1111 | 840 | (1500) | 4700 blue |
| 1250 | 980 | (1800) | 5700 yellow |
| 1430 | 1160 | (2100) | 7400 red |
| 1540 | 1270 | (2300) | 8500 infra-red |

It is known that with increasing temperatures the ultra-violet absorption band *does* advance into the visible. Unfortunately there are no numerical data available to check against the theoretical figures tabulated above.

One might suppose, therefore, that the somewhat parallel viscosity curves of the ordinary glasses are due to, or rather correlated with, a similar cut-off of the spectrum in the ultra-violet. This is the reason (or the consequences or the concomitant) of the fact that Twyman's glasses all tend to double in viscosity for a rise of 10°C or thereabouts; they all cut off at about the same point in the ultra-violet.

### III. The "Doubling-Interval" and the Absorption Band

The early investigators of the viscosity of glass, S. English and others, following Twyman, paid a good deal of attention to the "doubling-interval," that is the number of degrees C change of temperature needed to double the viscosity. This temperature-interval Twyman found to be around 10°C in the annealing range. Other investigators reported values between 8°C and 12°C, but it was soon established that the interval was much longer at higher temperatures. This follows, of course, at once from the equation

$$\eta = \eta_0 e^{\frac{L}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)} \quad \text{for putting} \quad \eta = 2\eta_0$$

$$2 = e^{\frac{L}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

or $$\log_e 2 = \frac{L}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right) = \frac{L}{R}\left(\frac{T_0 - T}{TT_0}\right) = \frac{L}{R}\cdot\frac{\Delta T}{T^2} \text{ approx.}$$

or $$\Delta T \text{ (the doubling-interval of temperature)} = (RT^2 \log_e 2)/L$$

or $$\Delta T = \frac{R \log_e 2}{Nh\nu}\cdot T^2 = \frac{0.693K\lambda}{hc}\cdot T^2 = 4.84 \times 10^{-9}\lambda T^2$$

That is, the doubling-interval varies directly as the wave-length of the absorption band and as the square of the absolute temperature. Thus the doubling-interval will be much less at room temperature than at the annealing point, if a meaning can be given to viscosity (of glasses) at room temperature.

Lillie takes the annealing point of his No. 1 glass at 509°C or 782°K. The author's calculations above show that the absorption band should be at 2370° Å for this glass.

Substituting these values of $\lambda$ and $T$ in the above equation, the doubling-interval at the annealing point is $\Delta T = 7.05$°C.

This figure applies also to Lillie's other two glasses.

This doubling-interval theoretically becomes very short at room temperature (about 290°K), since it is proportional to the square of the absolute temperature if $\lambda$ remains constant.

$\Delta T$ (at room temperature) $= 10° \ (290)^2/(782)^2 = 1.47$°C.

That is, the viscosity doubles in about $1^1/_2$°C.

NOTE: This is not entirely surprising, for pitch and similar materials vary at about this rate. From some old personal data of the author on mixtures of beeswax and resin used for making polishers for optical glass, the doubling-interval at room temperature is found to be 1.85°C. This would correspond to an absorption band at 3000 Å, or just beyond the violet of the visible spectrum. The material is slightly, perhaps one should say distinctly, yellowish, so that probably the absorption band extends into the visible spectrum.

Pitch is black by every ancient proverb, which means that its absorption band is right in the visible spectrum. As every worker in optical glass knows, its temperature-viscosity coefficient is high, but not so high as the wax mixture aforementioned. Trouton and Andrews (*Phil. Mag.*, **7** [Series 6], 347 (1904)) report viscosity of their pitch as increasing 7.6-fold in the interval from 15 to 8°C, *i.e.*, in a temperature range of 7°C. The doubling-interval, $\Delta T$, is accordingly 2.42°C, and the absorption band should be at 6170 Å, which is in the "orange" region of the spectrum.

This is near the brightest part of the visible spectrum, and the band is no doubt a wide one, which gives pitch its black color, for the whole visible spectrum is affected. There is, however, every reason to believe from the viscosity data that pitch is transparent in the infra-red and it may be transparent in the ultra-violet.

Glass technologists will no doubt be interested less in pitch than in glass, and these references to pitch are introduced simply to show that the doubling-interval of a degree or two postulated for glass at room temperature is actually observed in certain other amorphous glass-like substances. There is therefore no inherent improbability in the viscosity of glass behaving as postulated.

From Lillie's data, if the absorption band is any criterion, the viscosity of his No. 1 glass at 20°C would be approximately $10^{70}$ poises. Experimenters looking for evidence

of the bending of glass rods by viscous flow at room temperatures should reckon with viscosities of this magnitude.

**(1) Viscosity at High Temperatures**

The next consideration is why the curve should be a straight line up to about 650°C, and then should become increasingly curved.

NOTE: Before viscosity at high temperatures is considered, two or three points in connection with the fundamental formula may be noted, *viz.*,

$$\eta = \eta_0 e^{\frac{h}{K}\left(\frac{1}{T} - \frac{1}{T_0}\right)} = \eta_0 e^{\frac{h\nu}{K}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

If two materials have the same absorption band (equal values of $\nu$) then the ratio of their viscosities at any temperature is constant.

Secondly, as long as the straight-line law holds (which it presumably does, if the formula has any validity, as long as the absorption-maximum wave-length remains constant) the viscous behavior of any glass may be defined at any temperature in terms of two constants, $\eta_0$ and $\lambda$ or $\eta_0$ and $\nu$.

$\eta_0$ may arbitrarily be taken as the viscosity at 0°C (obtained by extrapolation) or at some other convenient temperature, *e.g.*, 500°C.

Note that $\eta_0$ is not a universal constant, but a property of the glass. It can probably be defined in terms of other properties of the glass, such as the infra-red spectrum, but there is no clue to this at the present time.

It is only fitting to point out that the position of the absorption band, as calculated, can be estimated without any reference to the latent heat ideas that appear in the earlier parts of this paper.

If it is found experimentally that $\eta = Ae^{b/T}$ as Andrade and Sharp have done, then such a formula will have no physical meaning unless $b = h\nu/K$, where $h$ is Planck's constant, $K$ is Boltzmann's, and $\nu$ is the frequency being sought. Thus with $b$ known from experiment, $\nu$ may be calculated.

The straight portion, in accordance with the author's theory, has been ascribed to a constant value of the heat of crystallization or polymerization over the temperature range where the straight part is found; that is, $L$ is constant.

This implies that the specific heat of the polymers is the same as the specific heat of the unpolymerized molecules. There are no adequate data on the specific heat of devitrite and sodium disilicate. For quartz, Sosman's data are available in the International Critical Tables. It appears that at room temperature quartz and vitreous silica have almost exactly the same specific heat. At lower temperatures quartz has a slightly lower specific heat, and at higher temperatures a slightly higher one. But quartz is only one of the normative minerals (and the least abundant of the three) of Lillie's glass at this temperature, and there is therefore no means at the present time in checking up on the constancy of the latent heat of the glass.[18]

Up to the eutectic point (725°C), however, the glass, if crystallized, will

[18] The normative composition of Lillie's No. 1 glass is devitrite (primary phase) 31.5%, sodium disilicate 51.5%, quartz 17.0%.

contain the same normative minerals, quartz, devitrite, and sodium disilicate, in constant proportions. At 573, quartz undergoes an inversion and at 678, sodium disilicate does also, so that the available energy of crystallization is reduced above these temperatures. It is not known whether or not devitrite undergoes an inversion within this range. But in any case the value of $L$ is reduced slightly at 573 and perhaps considerably at 678, as sodium disilicate amounts to more than half the normative composition.

Thus the straight-line relation should be expected to cease to hold, and the slope to become less steep. This in fact is what is found. The softening point is given by Lillie as 670, and this on the curve (Fig. 4) seems to be just about the end of the straight-line portion.

It is interesting, and possibly significant, that the softening points of all three of Lillie's glasses come very close to this inversion point of the sodium disilicate, the values being 670, 679, and 655 (Lillie's own figures, not the ends of the straight lines on the author's curves), while Kracek gives the inversion point as 678. There may, therefore, be some connection.

At 725°C the ternary eutectic point observed by Morey and Bowen is reached, and above this temperature the normative composition is devitrite, sodium disilicate, and "glass" (fluid) in continually varying amounts. The polymerized molecules that have been envisaged as forming in the fluid are now not necessarily incipient crystals of the three normative minerals. $L$ becomes not the heat of crystallization of known minerals, but the heat of formation of somewhat uncertain molecular groupings. They are, so to speak, heats of solution rather than heats of crystallization.

The slope of the curve therefore may be expected to change continually with increasing temperature.

The course of the curve at the other end, *i.e.*, at lower temperatures, also offers opportunity for speculation. "Viscosity" as ordinarily defined ceases to have a meaning below the lowest temperatures at which Lillie and Stott have measured it. The glass can not be made to flow through a capillary; it can not be stirred in a platinum crucible or even twisted viscously in rod form. But if a quantity, $\eta$, can be defined by the function $d(\log\eta)/d(1/T) = L/R$ without any reference to flow, and if $L$ can be defined in terms of the position of the absorption band, then there is no apparent reason why $\eta$ should not be measured down to absolute zero by observing the absorption band.

If this band stays in place with lowering temperature and does not migrate around the spectrum or vanish altogether then $L$ is constant, and $\eta$ is given at any temperature by $\eta = \eta_0 e^{\frac{L}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$ and putting $T = 0$, the "viscosity" becomes infinite at absolute zero.

## Appendix I

The vapor pressure of fluids is given by a formula of exactly the same type: $d(\log_e p)/dT = l/RT^2$, where $l$ is the latent heat of evaporation.

The constant of chemical equilibrium similarly: $d(\log_e \kappa)/dT = u/RT^2$, where $u$ is the energy change at stake in the reaction.

$\kappa$, $p$, and $\eta$ are all merely measures of the point at which molecular combination in a reversible reaction comes to equilibrium with the radiant energy density. In more simple language $p$, the vapor pressure, measures the willingness of the liquid to become a gas, and $\eta$ measures its willingness to become a solid.

## Appendix II

A note on "dimensions."

Log $\eta$ is a meaningless expression. It is quite impossible to take the log of a viscosity or any other *physical* quantity.

But $d(\log \eta)$ or $\Delta(\log \eta)$ is perfectly sound, since it amounts to $\log \eta_1 - \log \eta_2$ and this is $\log (\eta_1/\eta_2)$ or the log of a ratio, which is a pure number.

For this reason it is quite immaterial in what units the viscosity is measured (for the present purpose). $\eta$ may be measured in English units or French units, or purely arbitrary units, and any other system of units may be chosen for $L$, $R$, and $T$. All will give the absorption band at the right place. It is merely necessary that $L$, $R$, and $T$ be kept consistent.

## NOTE ON VISCOSITIES OF THE ORDER $10^{20}$ POISES

It is suggested in the paper that at room temperature, Lillie's glass would have a viscosity of this magnitude; as the figure means little by itself, being of a different order of magnitude from anything previously encountered, the following observation is made:

The velocity of light is 186,000 miles a second or $3 \times 10^{10}$ cm./sec.

The oldest known rocks on this earth are some 2000 million years old, or $6.3 \times 10^{16}$ seconds. In this time light would travel $1.9 \times 10^{27}$ centimeters. That is, 2000 million light years represent this number of centimeters. It is not certain how large the universe is and it may not hold a straight line as long as this. Suppose, however, that it would, and that at the creation of the world a glass fiber had been made to Lillie's specifications as long as this. Then for 2000 million years, or the duration of time (on this earth) let this fiber be kept at 20°C, and loaded with as big a load as is safe, *i.e.*, 5000 lb./sq. in. or $3.5 \times 10^{10}$ dynes/cm.$^2$

Then if the viscosity were $10^{20}$ centimeter-gram-second units, the fiber by this time would have stretched viscously to the extent of $1.4 \times 10^{-10}$ centimeters, or less than one-thousandth part of the diameter of an electron.

Two deductions follow from this:

(1) Viscosities of this order have no physical meaning in mechanical terms, but only as probability functions.

(2) The attempt to induce a permanent set of measurable amount in a glass rod one yard long at room temperature in the course of a year or two is not likely to lead to positive results. The phenomena discovered by Mr. Spencer are thus almost certainly not phenomena of viscous flow in the ordinary sense of the word; they must be something totally different, and possibly much more significant.

BUTLER, PA.

# CHROMIUM GREEN STAINS*

By E. C. Hill

ABSTRACT

A series of experiments was made to modify the formula for light green (Victoria green) underglaze color recommended by Seger and to simplify the preparation of the stain in large quantities for terra cotta production. Four compositions were found which could be used as a substitute for Seger's underglaze green.

## I. Introduction

To produce uniform chromium green colors for terra cotta, it is necessary to prepare a stain or calcine, generally Seger's[1] light green (Victoria green) underglaze color, as follows:

| | |
|---|---|
| Potassium bichromate | 36 |
| Calcium chloride (fused) | 12 |
| Finely ground quartz | 20 |
| Marble | 20 |
| Fluorspar | 12 |
| | 100 |

Quartz, marble, and fluorspar are first finely ground and then, after decanting off the water as much as possible, treated with a hot saturated solution of calcium chloride and potassium bichromate, the whole being evaporated to dryness. The dry mass is well rubbed together in a porcelain mortar and then fired at as high a heat as possible.

This stain, always satisfactory, is difficult to prepare in large batches.

## II. Difficulties with the Seger Formula

Fused calcium chloride is difficult to obtain, and its preparation in the plant is costly, since it must be fired at a low heat to prevent volatilization. The anhydrous form is therefore generally used.

The first attempt to prepare a 100-pound batch of this stain as directed by Seger, that is, by grinding flint, whiting, and fluorspar with water in a ball mill and adding the potassium bichromate and calcium chloride as a saturated solution, resulted in the soluble materials separating out and forming a hard crust when dried on steam pipes. This mixture could not be ground dry in a ball mill because the calcium chloride took up water and formed a moist mass which caked in the mill.

Subsequent experiments have shown that the best method of preparing the stain is to mix the materials dry by sieving by hand through a 20-mesh sieve. The calcium chloride usually comes in 50-pound sealed tins in the form of crystals about $^1/_8$ inch in diameter. This is put through a small hammer pulverizer, screened to pass a 20-mesh sieve, and stored in the tins to prevent the material taking up water from the air. Powdered

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[1] Seger's Collected Writings, Vol. II, p. 662.

potassium bichromate is used. This material, in powdered form at least, is very irritating to the throat and lungs, and the task of mixing the stain through sieves by hand is unpleasant and becomes injurious when large amounts of the stain are to be prepared at one time.

## III. Experimental Stains

The series of experiments reported here were to determine whether calcium chloride could be eliminated from the stain, since, if calcium chloride were not used, the materials could be ground dry in a ball mill, instead of mixing by hand; also, to determine whether chromium oxide could be substituted for potassium bichromate.

Series 1

| | 1 | 1X[a] | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Potassium bichromate | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| Flint | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 30 | 10 |
| Fluorspar | 12 | 12 | 24 | 12 | 18 | | 44 | 13 | 23 |
| Whiting | 20 | 20 | 20 | 32 | 26 | 44 | | 21 | 31 |
| Calcium chloride | 12 | 12 | | | | | | | |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

[a] 1X has refined calcium chloride.

Series 2

| | 9 | 10–15 |
|---|---|---|
| Chromium oxide | 18.6 | 18.6 |
| Flint | 20 | 20 |
| Fluorspar | 23 | 15.5 |
| Whiting | 38.4 | 25.9 |
| X[b] | | 20 |
| | 100 | 100 |

[b] X in the test batches 10 to 15, inclusively and respectively, was (10) soda ash, (11) sodium chloride, (12) cryolite, (13) borax, (14) potassium nitrate, and (15) white lead.

In Series 2, chromium oxide ($Cr_2O_3$) is used in the amount equivalent to the chromium oxide in potassium bichromate ($K_2Cr_2O_7$).

One hundred ounces of each stain were prepared by mixing by hand through a 20-mesh sieve four times. The stains were placed in saggers two inches deep and 12 inches in diameter. These were placed in the kiln in two stacks of eight saggers each, with slabs on the top sagger, so that all were covered. They were fired to cones 6 to 7 in a 6-foot kiln.[2]

Numbers 12 and 13 were very hard, and it was necessary to break up

[2] Stains of this type can not be fired in a regular terra cotta kiln because the fumes may discolor the ware. In the kiln in which these stains were fired, there were about 1200 pounds of other stains. The fumes attacked the cones, so that when these stains were fired, only cone 5 was down, although the pyrometer showed a temperature corresponding to between cones 6 and 7. The sight cones at the trial holes had cone 7 started. When the kiln was drawn, the inside cones were colored green and showed some blistering.

the sagger and grind off the broken pieces of sagger with an abrasive wheel. The stains were put through a small jaw crusher and reduced to about $^1/_8$-inch diameter, and were wet ground in a ball mill for six hours. Number 13 had to be reground after breaking up the larger particles. After standing overnight, the water was slowly poured off each stain, fresh water added, the mixture shaken, and allowed to settle. This was repeated three times to remove the soluble material, but when the stains were dried, there was a very thin film on the top of each stain.

There was a considerable loss in weight in calcining due to boiling and fusing. Some of the stain was lost by adhering to and permeating the sagger. The proportionate loss from the latter course would be considerably less if larger saggers were used. The percentage of dried stain remaining after grinding was as follows:

| | | |
|---|---|---|
| (1) 52 | (6) 67 | (11) 54.5 |
| (1X) 57 | (7) 61.5 | (12) 69 |
| (2) 52.5 | (8) 39 | (13) 62.5 |
| (3) 47.5 | (9) 73.5 | (14) 56.5 |
| (4) 54 | (10) 48.5 | (15) 63.5 |
| (5) 43.5 | | |

A series of glazes was prepared by adding 10% of the various stains to a base glaze of the following composition:

| Base Glaze | |
|---|---|
| Soda feldspar | 48 |
| Whiting | 15 |
| Barium carbonate | 6 |
| Ky. ball clay | 5 |
| English china clay | 9 |
| Flint | 20 |
| | 103 |

These were made in 50-ounce batches, ground for one hour in laboratory jar mills, and sprayed on small trials and 16- by 8-inch machine ashlar. The trials were fired in three kilns to cone 6, and the results reported are an average of the three firings.

## IV. Results

SERIES 1 POTASSIUM BICHROMATE

| Glaze No. | Description |
|---|---|
| 1 | Trifle lighter color than No. 1X |
| 2 | Much lighter than No. 1 (duller glaze) |
| 3 | Deeper than No. 2; lighter than No. 1 |
| 4 | Trifle deeper than No. 3; lighter than No. 1 |
| 5 | Dark gray-green color (entirely different from other colors in the series) |
| 6 | Light gray-green (glaze not mature) |
| 7 | Lighter than No. 1 (nearest to No. 1 of any with potassium bichromate) |
| 8 | Deeper than No. 6 (lighter than the others; glaze trifle immature, but better than No. 6) |
| 2, 3, 4, and 7 | Good colors; 4 and 7 best (except No. 1) |

Eliminating the calcium chloride reduced the depth of color slightly. A combination of whiting and fluorspar in somewhat similar proportions as in Seger's formula gave the best greens. When all the lime is derived from whiting, the color becomes a dark brownish green. When all the lime is introduced as fluorspar, the color is a very light gray-green, and the glaze is immature. Increasing the flint and decreasing the whiting and fluorspar an equal amount deepened the color and gave a brighter color. Decreasing flint and increasing fluorspar and whiting lightened the color and tended to cause the glaze to be immature.

SERIES 2 CHROMIUM OXIDE

| Glaze No. | Description |
|---|---|
| 9 | Much lighter than No. 1 (texture duller) |
| 10 | Trifle more grayish than No. 1 (has same color depth) |
| 11 | Slightly deeper green than No. 1 |
| 12 | Grayish green (somewhat immature) |
| 13 | Lighter than No. 1 (deeper than No. 9) |
| 14 | About same color as No. 1 |
| 15 | Deeper color than No. 1; very slightly deeper than No. 11 (texture trifle smoother than No. 11) |

In Series 2, all are good colors except No. 12. Numbers 9 and 13 are too light to substitute for No. 1, and No. 10 is slightly grayish, although a good color. Numbers 14, 11, and 15 are good colors, and vary in depth in the order mentioned. These three, with No. 7 in Series 1, are in the range of color obtained by successive batches of No. 1 stain.

The cost of these stains at current wholesale prices in the raw batch and as dry calcined stain, based upon the amount obtained in these experiments are as follows:

| | (1) | (7) | (11) | (14) | (15) |
|---|---|---|---|---|---|
| 100 lb. raw batch | ($)4.45 | 4.00 | 5.97 | 7.09 | 7.02 |
| 100 lb. dry calcine | ($)8.56 | 6.50 | 10.95 | 12.37 | 11.05 |

## V. Conclusion

In conclusion, it is suggested that it might be advantageous in any future work to determine the effect of increasing flint in stains using both potassium bichromate and chromium oxide; also the effect of varying amounts of the most promising fluxing materials in these experiments, as well as other fluxing materials, since the flux used has a decided effect on the color.

CONKLING-ARMSTRONG TERRA COTTA CO.
PHILADELPHIA, PA.

# MISCELLANEOUS TERRA COTTA LABORATORY NOTES*

By H. R. Goodrich

ABSTRACT

The following points are discussed in this paper: (1) green scumming, (2) black ash as a substitute for barium carbonate, and (3) colemanite overglazes for polychrome.

## I. Further Notes on Green Scumming

**(1) General**

E. R. Curry[1] has reported the results of an investigation of a water-soluble green scum known to form on the fired clayware from several localities. Being soluble the scum-forming materials are carried and deposited on the surfaces by the evaporation of any water that has soaked the ware.

The characteristic color of the scum at first is a pale greenish yellow which deepens over a period of days to a dark green after which time it becomes difficult to remove it from the ware. The principal colorant of the scum was shown by Curry to be salts of vanadium with smaller amounts of molybdenum salts present. These scum-forming salts are present in several of the clay deposits of California, including the diatomaceous earth deposits of Lompoc, the sand deposits of Ione, and the clay deposits of Lincoln.

Various methods to prevent scum on fired ware were suggested by Curry, the most promising of which were subsequently found to be the addition of white lead to the clay mix before pugging or by dipping the fired ware in a potassium carbonate solution.

**(2) Prevention of Scum**

Since Curry's tests, the method of preventing the appearance of the green scum has been fairly well standardized and approved as satisfactory and economical. A method for the removal of the scum from old installations where it has caused discolorations has also been found.

The first method tried commercially for the prevention of the scum was the addition of approximately $^1/_2\%$ white lead to the body before pugging. Experiments had indicated that this would greatly decrease the amount of the scum but would not entirely prevent it. After a period of years of this practice, during which time a certain number of cases were encountered where the fired ware tended to scum, it was decided to adopt the practice of dipping in potassium carbonate solution. The experiences of other plants also indicate that dipping is efficient in the prevention of scum.

No case of green scumming has been reported since the practice of dipping has been followed at this factory. Various strengths of solutions, between

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Terra Cotta Division). Received February 26, 1932.

[1] "Notes on Green Scumming," *Jour. Amer. Ceram. Soc.*, 9 [6], 392–97 (1926).

0.6 and 8%, have been used. In recent tests it was found that no scum would appear on terra cotta that had been dipped in a 0.25% solution, while duplicate undipped pieces scummed freely. As the cost of the weaker solutions is quite small, dipping solutions of 1.0 to 1.25% strength on the basis of weight of potassium carbonate to weight of water have been adopted as standard which allows a safety factor over the experimental results.

The potassium carbonate being used is purchased as "potassium carbonate, calcined, 96 to 98% pure," at a cost of 6 to 7 cents per pound.

**(3) Dipping Method** Several methods may be worked out for an economical dipping of different clay products. The process of dipping terra cotta at this factory was simplified by equipping all the trucks used in unloading or drawing the kilns with loose top decks. A movable motor hoist is used to lift the loads which are then shoved in position over a cement tank and lowered into the dipping solution. After being allowed to drain over the tank for a moment the loads are lowered back to the truck for movement to the fitting house or storage yard.

**(4) Costs** While the complete prevention of the formation of the green scum was the primary reason for adopting the practice of potassium carbonate dipping, it has also been found to be more economical than the use of white lead. The following data give the comparative costs of the two materials in commercial practice:

COST PER TON OF FIRED WARE

| Process | Labor | Material | Burden | Total |
|---|---|---|---|---|
| Addition of white lead (approx. 0.5%) | | $0.70 | | $0.70 |
| Dipping in potassium carbonate solution (1.25%) | $0.10 | 0.035 | $0.06 | 0.195 |

It is evident that the dipping method may be followed at a cost of less than one-third that of the white lead method. The former in addition is fully effective while the use of white lead is not.

**(5) Removal of Green Scum** Certain old installations of brick or terra cotta, manufactured previous to the general use of potassium carbonate dipping, have been known to green scum, and the satisfactory removal of such scum has been a problem that various manufacturers have had to meet. The scum itself has been found to be soluble in various acids but in the necessary treatment of only one face of the material in a building the general behavior of such solvents is to dissolve the scum and carry it back into the body of the material. While the acids are drying, however, the scum reaccumulates on the face usually in a more vivid color than before the treatment.

Under the direction of A. Lee Bennett a treatment was developed which has been successfully used to remove the scum from a brick building.

A nitric acid, hydrogen peroxide solution did not intensify the color of the scum as did hydrochloric and sulphuric acid solutions. All three solutions dissolved the scum and temporarily removed it from the surface. A potassium carbonate solution applied to the surface after the acid treatments failed to prevent the scum reappearance, but a waterproofing compound called "Minwax" similarly applied was used with success.

The method finally adopted was first to brush the brick surfaces with a 5% nitric acid, 5% hydrogen peroxide solution until the scum was dissolved and absorbed by the brick and mortar joints. Approximately three square feet were cleaned at one time, and immediately, while still damp, the brick and mortar joints were thoroughly saturated with clear "Minwax" to waterproof the surface. This treatment has prevented the reappearance of the scum and it is believed that if any scum eventually does work through the waterproofing it may be easily washed from the waxed surface.

## II. Black Ash as Substitute for Barium Carbonate

An interesting experiment has been made on the practicability of using black ash (crude barium sulphide) or the black-ash residue as a substitute for barium carbonate in clay bodies. A preliminary test was made by introducing barium carbonate, black ash, and black-ash residue in increasing increments at 0.125% intervals into small batches of a clay that was known to scum copiously. The fired samples without any precipitant present were coated with a heavy white scum which decreased gradually and finally disappeared as the three precipitants increased. The following relationship was established in regard to the effectiveness of the materials: 0.625% of precipitated barium carbonate prevented all scumming as did also 0.50% of the black ash and 3.5% of the black-ash residue. In examining the results of this test the barium carbonate was favored and it is possible that the black ash was slightly more effective than stated.

The following table gives the comparative costs and possible savings on the basis of this test with prices delivered at this factory:

| Material | Per cent required | Cost/ pound | Pounds/ ton of ware | Cost/ton of ware | Saving over barium carbonate (%) |
|---|---|---|---|---|---|
| Barium carbonate | 0.625 | $0.031 | 12.5 | $0.3875 | |
| Black ash | 0.50 | 0.022 | 10.0 | 0.22 | 43.25 |
| Black-ash residue | 3.5 | 0.0045 | 70.0 | 0.315 | 18.75 |

A commercial test of the black ash was next made by substituting it for barium carbonate in a roofing-tile mix. This first test was successful with the exception of the objectionable sulphide odor formed at the pug mill when the black ash came in contact with the water. This odor was not noticeable to a great extent on the extruded tile.

A second commercial check run was later made in a larger quantity and on these tile it was found that the coarse black ash appeared on the

fired tile in small white specks similar to lime spots. Apparently the material had not been dissolved sufficiently in the coarse grinding and rapid pugging that this roof tile body receives.

In both tests the black ash prevented all appearance of scum. It therefore appears that this material offers a substantial saving but should either be more finely ground before adding, or predissolved to insure the thorough breaking down of the particles. The odor of the black ash is disagreeable but might not prove objectionable to the workmen after they are accustomed to it.

Regarding the use of this material in hand-pressed clay bodies, it is reported to be more poisonous than barium carbonate due to its high solubility. The possible saving by its use as a substitute for barium carbonate warrants a fuller investigation for use in machine-made products.

### III. Colemanite Overglazes for Polychrome

An interesting palette of overglaze colors has been developed by combinations of raw colemanite with various terra cotta stains and underglazes or other colorants. The colemanite serves as a flux and also as an excellent suspending medium producing overglazes which handle nicely with a brush or which may be sprayed. These overglazes are usually characterized by small segregations of color similar to an artist's or engraver's stippling, which effect is pleasing and adds character to the colored areas.

In the preparation of the overglazes, the colemanite and the insoluble coloring materials are screened dry through a 100-mesh screen. Test batches of 20 grams of colemanite are used with varying weights of colorants usually from 2 to 40 grams. A 25% glycerine, 75% water solution is added to bring the volume of the suspension to 100 milliliters. After shaking and dissolving the soluble colorants, the overglaze is ready for application. The application may be made over any type of raw terra cotta glaze by painting in one coat on small areas and spraying in one coat on the large areas.

The colorants used successfully include well-known brands of prepared cone 6 underglazes and stains and also several fine-ground or precipitated insoluble chemical colors such as the cobalt, copper, and manganese carbonates, and sodium uranate. Many blends of these may be used to give various color effects. Soluble salts of the usual type used in soluble-salt polychroming have also been used with the colemanite, usually in combination with the above insoluble colorants. The soluble materials have the disadvantage of not being removable from the areas where not desired.

The advantages of these overglazes include their ease of preparation and application and their interesting surfaces. The uranium-iron yellows are particularly strong and pleasing. One disadvantage is that they tend to lower the resistance of the underglazes to crazing.

GLADDING, MCBEAN & CO.
LINCOLN, CALIFORNIA

# DISCOLORATION OF A TERRA COTTA GLAZE*

By T. E. Nicholson

ABSTRACT

This paper deals with a peculiar discoloration of a typical terra cotta glaze. The method of solving the problem is outlined, and conclusions are reached which point out methods of prevention of similar defects.

## I. Introduction

All colored glazes have a tendency to have a variation in color, both in strength and hue, but this variation must be kept within certain limits. Certain glazes are more susceptible to these changes and to discoloration than others, and must be applied and fired with greater care. Other glazes are not properly balanced and must be altered before a uniform color can be produced.

Glaze thickness plays an important part in developing uniform color. Generally speaking, a heavy application of a colored glaze will produce a darker color than a light application of the same glaze, although the opposite is true with a few glazes.

The atmospheric condition of the kiln is an important factor in producing a given color. The presence of too much steam causes the average terra cotta glaze to appear immature, especially on the edges of the ware, and will also increase the fuming action of any volatile constituents in the glaze. Volatile colorants which have been precipitated upon the walls and kiln furniture during previous firings will also be re-volatilized and will react with the glaze on the new ware, causing discoloration and variation.

## II. Conditions

One particular glaze formula which produced a warm gray speckled mat finish has shown a dark gray-brown smoky discoloration. This glaze was applied to a thickness of 0.022 inch in order to reduce the dry edges resulting from steam in the kiln. The discoloration was not noticeable on small-size samples but occurred on full-size samples in the form of an irregular streak from three to eight inches in width, while the remainder of the surface was more satin in texture and was absolutely free from any discoloration. This discoloration could be practically eliminated by refiring, but the area that had been off-color was more mat than the surrounding area.

Thin sections were examined under a "zeichenokular" microscope and the discolored area appeared to have been caused by a strewing out of the manganese specks. Cross-sections gave the impression that this

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Terra Cotta Division). Received February 26, 1932.

color change was not a surface condition but extended down through the total glaze thickness. This would indicate that the glaze in the discolored areas had been more fluid and had caused the manganese specks to disintegrate, while in the other areas the specks had kept their original form.

Samples were fired at various temperatures and it was found that the discoloration was darker but covered the entire piece when the glaze was slightly underfired. Higher temperatures decreased the size of the discolored areas but did not minimize the defect.

Draw trials were sprayed with this glaze and fired in the regular manner. One-half of each draw trial was drawn from the kiln during the cooling when the temperature had dropped to about 1300°F (dull red heat) and the other half left in the kiln to cool according to regular schedule. The halves which were drawn hot were fairly mat in texture and were entirely free from discoloration, while the other halves which were allowed to cool slowly showed considerable discoloration. This fact was considered as an indication that the discoloration was a surface defect and did not extend into the body of the glaze.

Discolored areas on large samples were treated with hydrofluoric acid and the treated area lost its discoloration. Sandblasting was equally beneficial. This was quite definite proof that the discoloration was a surface defect, contrary to the results of the petrographic study.

## III. Experimental Glaze Tests

As it was thought possible that the lot of feldspar which was being used had altered, tests were run using the same formula with an old lot of feldspar. These samples developed more discoloration than the samples using the regular feldspar.

Experiments were run using a new feldspar which was much harder, being lower in soda and higher in potash. The molecular ratio formulas for three of the experimental bases, together with the original base glaze, *A*, are as follows:

| | *A* | *B* | *C* | *D* |
|---|---|---|---|---|
| $K_2O$ | 0.124 | 0.117 | 0.129 | 0.156 |
| $Na_2O$ | 0.089 | 0.134 | 0.037 | 0.046 |
| BaO | 0.101 | 0.014 | 0.038 | 0.080 |
| MgO | 0.050 | 0.137 | 0.049 | 0.057 |
| CaO | 0.348 | 0.236 | 0.288 | 0.337 |
| ZnO | 0.288 | 0.463 | 0.459 | 0.324 |
| $Al_2O_3$ | 0.431 | 0.404 | 0.348 | 0.445 |
| $SiO_2$ | 2.635 | 2.332 | 2.075 | 2.618 |
| $SnO_2$ | 0.0625 | | 0.081 | 0.042 |

Other experiments were run with many different base glazes and variations in the composition. All glazes which contained 0.1 mol of barium, or more, developed this typical discoloration to a greater extent as the barium was increased. Satin-mat glaze formulas containing around 0.12

mol BaO and 0.25 mol ZnO developed more discoloration than the original base mat. All experiments indicated that a glaze high in barium and low in zinc was more easily overloaded with stain and more susceptible to discoloration from any reducing conditions in the kiln.

Glaze *B*, low in calcium and high in magnesia and zinc, was quite hard and developed a satin-mat texture. Also, it was impossible to produce the desired color (partially due to the lack of tin oxide) on account of the low calcium and barium.

Glaze *C* was quite an improvement over either glazes *A* and *B* in that it was possible to produce the desired color with very little discoloration. The viscosity, however, being too low at the maturing temperature, caused the specks to flow giving a streaked instead of a speckled appearance. This glaze matured to a good even mat and had a range of about four cones with only a slight variation in texture but a greater variation in color.

Glaze *D* has proved to be a very good glaze. The higher potash and lower soda content in the feldspar, together with an increase in zinc at the expense of barium, holds the texture quite uniform. The other changes in the formula are incidental to procuring proper glaze fit and matness. It is possible to overload this base glaze with stains and get quite similar discoloration to that encountered with glaze *A*; this glaze with the proper stains, however, has been used repeatedly with no defects. It has been found advantageous to use manganese screenings, which are free of all −100-mesh material, since the speck size is more uniform and a smaller blunge is necessary to produce the desired color.

## IV. Conclusions

The foregoing experiments indicate that the following conditions are necessary to produce this finish without danger of discoloration:

(1) The glaze must have a very uniform mat texture.
(2) The glaze must not be overloaded with stain.
(3) The zinc content must be considerably higher than the barium content, and the latter should not exceed 0.09 mol.
(4) The glaze must be applied uniformly and the thickness must be kept at a minimum, consistent with good covering qualities.

**Acknowledgment** The author is indebted to Ross D. Plank, of the Los Angeles Plant, and to Hewitt Wilson, of the Department of Ceramics, University of Washington, for advice and assistance, and to G. E. Goodspeed, of the Department of Geology, University of Washington, for petrographic work.

GLADDING, MCBEAN & COMPANY
AUBURN, WASHINGTON

# MICROSCOPIC TECHNIQUE IN THE INVESTIGATION OF ENAMEL COATING AND SOME OBSERVATIONS*

By G. W. McGohan

ABSTRACT

The polishing equipment and the technique of polishing specimens of vitreous enameled metal are described. A discussion is given of the characteristics of various enamel defects which are illustrated by photomicrographs.

## I. Introduction

The application of the inverted type of metallurgical microscope to the study of vitreous enamel coatings is fairly recent. For a long time attempts have been made to polish specimens of enamel coatings using the technique that is ordinarily used in preparing samples of iron and steel. Most of these attempts have resulted in failure, due primarily to the difficulty of preparing and illuminating the specimens with vertical illumination so that maximum detail could be obtained. The first real clue to the solution of the problem of preparing these specimens of vitreous enameled iron came from a paper by R. G. Guthrie[1] in which the use of a paraffin disk for preparing specimens of iron and steel for microscopic examination at high magnifications was described, a technique applicable to the present case. J. O. Lord and W. C. Rueckel[2] have described a technique for polishing specimens of enameled iron, similar in many respects to the technique to be described.

The importance of the speed of the various polishing disks, particularly that of the paraffin disk, in obtaining flat specimens, and the importance of decentered critical illumination of the specimen to obtain the maximum detail have not been previously emphasized, though found important here.

## II. Polishing Equipment

The equipment for preparing microscopic specimens consists of a three-spindle, direct motor-driven disk, polishing table. The speed of each motor is controlled by a rheostat and has a range of from 700 to 1900 r.p.m. There is also a grinding stand on which are mounted cup grinding wheels and a special direct motor-driven grinding disk on which emery cloth is used.

**(1) Paraffin Disk** The paraffin disk is made up by casting a layer of paraffin about $^1/_2$ to $^3/_4$ inch thick on the disk. After the paraffin has cooled the disk is placed on the spindle, dressed smooth with a straight edge, and then knurled with a hot knurling tool as shown

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Enamel Division).

[1] *Trans. A.S.S.T.*, **25**, 337–41 (1925).

[2] *Jour. Amer. Ceram. Soc.*, **14** [10], 777–81 (1931).

in Fig. 1. The purpose of this knurling is to hold the abrasive on the disk.

During hot weather pure paraffin is too soft for use. Under these conditions 25% stearic acid should be added to the paraffin to harden it.

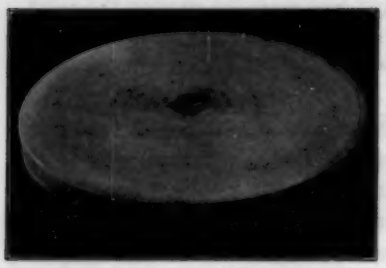


FIG. 1.—Paraffin disk ready for use.

Levigated alumina in a soap solution is satisfactory as a polishing abrasive. This soap solution is made up by dissolving 6 bars of a glycerine base soap in 5 gallons of hot water and then adding ½ gallon of glycerine to the solution. The soap solution acts as a lubricant and keeps the sample from sticking to the paraffin disk. About 10 grams of levigated alumina are added to about 250 cubic centimeters of the soap solution. The abrasive solution is applied to the disk with an ordinary paint brush, or by dripping the solution on the disk from a wash bottle.

## III. Selection and Mounting of Samples

The interpretation of the results of microscopic examination depends largely on the selection and polishing of the sample. Too much stress can not be placed on the selection of the proper sample for often misleading results will be obtained if the sample is not properly selected.

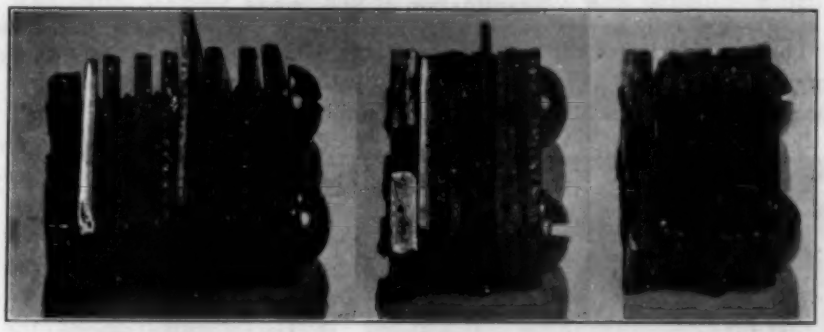
After a sample, representative of the defect or condition to be investigated, has been selected, it is sawed out with a fine-tooth hand hack-saw. The sample should be supported on both sides by blocks of soft wood while it is being sawed, then cut to the desired size.

**(1) Mounting** The sample is mounted in low melting point alloy, sealing wax, or between pieces of celluloid. The use either of a low melting point alloy that expands when cooled or of celluloid is preferred. The mounting of the samples between pieces of celluloid is especially desirable when defects, such as copper spots, are to be polished. When samples are mounted in this manner, the defects may be observed and the polishing stopped when the defect is reached.

Figure 2 shows the method of mounting specimens between pieces of celluloid. A, B, and C show progressive steps in the preparation of the sample.

Another particular advantage of mounting the specimen between layers of celluloid is that the celluloid polishes down rapidly and therefore permits a faster cutting of the sample which minimizes the difference in the optical plane of the enamel and base metal.

Samples should always be mounted so that the polishing is at right angles to the enameled surface of the sample.



A B C

FIG. 2.—Progressive steps in mounting specimens between pieces of celluloid.

## IV. Polishing of Specimens

After the proper sample has been selected and mounted, the specimen is filed flat with a standard mill file. The filing is done so that the enamel is always pressed against the base metal. Usually the filing is done at a right angle to the face of the specimen.

The specimen is next ground on a disk covered with emery cloth. The speed of this grinding is about 800 r.p.m. This grinding is done at 45° to the scratches put in the specimen by the filing in order to be able to see when all of the filing scratches are removed.

The next operation is to polish the specimen on the paraffin disk. This time the specimen is held so that the polishing is either 45° or 90° to the scratches put in by the previous grinding operation, but always so that the enamel is pressed against the base metal.

This step in the polishing is the most important in the procedure and considerable care should be taken. Enough time should be spent on the disk to remove all the cracks in the enamel that might have occurred in previous operations.

The best results are obtained on this disk by fast polishing (about 1800 r.p.m.) and by using plenty of abrasive. By polishing at this speed it has been possible to eliminate the difference in level of the base metal and enamel, which is one of the most common difficulties.

The final polishing is performed on a disk covered with a billiard table cloth using stick jeweler's rouge as the abrasive. The direction of polishing on this disk is immaterial as the object is to remove scratches both in the enamel and in the base metal. It is very seldom that any chipping

or cracking of the enamel occurs in the final polishing when proper care is used.

## V. Examination of Specimens

The examination of the specimens is made with an inverted type metallurgical microscope. (See Fig. 3.) Very little information is obtained at magnifications below 500 diameters and most of the work is done at 500 diameters. Magnifications of 1000 diameters and higher are often employed, however, to study some of the finer details that are not resolved at 500 diameters.

FIG. 3.—Inverted type metallurgical microscope.

The illumination of the specimen is important and most of the photomicrographs were taken with decentered critical illumination. This is accomplished by an iris diaphragm which is mounted in front of the illuminating source and which can be decentered and rotated to give the best results.

The time of exposure of the negatives is also important. The usual tendency is to expose the negative so that the base metal has the proper density which under-exposes the enamel. The enamel requires approximately ten times the exposure of the base metal. Thus for good photomicrographs of enamel it is necessary to over-expose the base metal.

By proper mounting and preparing of specimens of enameled iron for microscopic examination, it has been possible to determine the mechanism for many of the defects that occur in an enameling plant. Such defects as copper spots, primary boiling (boiling occurring during the first firing of the ground coat), secondary boiling (black specks), and fishscaling, have been studied and the mechanism of their formation deduced.

Other important factors such as the amount of free iron oxide at the interface of the enamel and base metal, size, number, and distribution of bubbles in the enamel, the amount and depth of penetration of the iron oxide in the enamel, etc., all affect the strength, ductility, and adherence of the enamel and may be studied only by the microscope after suitable preparation of the sample.

## VI. Characteristics of Some Enamel Defects

**(1) Copper Spots** Copper spots or copperheads are caused by an excessive oxidation of the surface of the base metal in localized areas. Figure 4 shows an area across the interface of the base

metal and enamel in a copperhead. The large amount of unabsorbed iron oxide is evident.

The cubic crystals in the enamel are magnetite and hematite which have been dissolved in the enamel at the higher temperatures and have crystallized during the cooling period.

The characteristics of a copperhead are somewhat as follows:

As the copperhead is approached, a few crystals of iron oxide are found. Toward the copperhead, these crystals increase in quantity until eventually

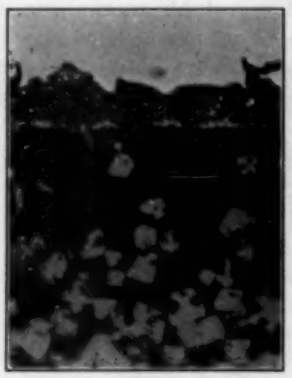


FIG. 4.—500×.

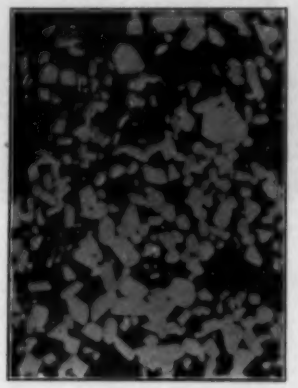


FIG. 5.—500×.

the entire structure is made up of them. Still closer to the copperhead large amounts of unabsorbed iron oxide are found at the surface of the sheet and the structure in the center of the copperhead is almost all magnetic oxide.

Figure 5 shows the same types of crystals as those shown in Fig. 4. These crystals were produced synthetically by adding 50% $Fe_2O_3$[3] to a commercial ground coat, and begin to appear in enamel when approximately 25% $Fe_2O_3$ is added.

Thus from these microscopically observed facts, the mechanism of copperheading is found to be simply excessive localized oxidation of the base metal in such amounts that the fusion point of the enamel is raised above the firing temperature. The formation of these crystals may readily be followed by microscopic examination.

**(2) Primary Boiling** The primary boiling is that boiling which occurs in the ground coat on the initial firing. This results in irregularities which do not smooth down on continued firing. The term "primary boiling" is used to distinguish this behavior from the so-called reboil (boiling that causes black specks).

[3] The $Fe_2O_3$ is reduced during the smelting to $Fe_3O_4$.

Figures 6 and 7 illustrate the microscopic appearance of primary boiling.[4] The appearance of the defect is shown by the formation of a very large bubble in the enamel, extending from the interface to the surface of the enamel; directly under this bubble in the base metal is a large area of pearlite. In this pearlite some free iron oxide is present. It is unusual for a condition such as this to occur in pure iron, but it occurs frequently in steels.

FIG. 6.—500×.

The possible mechanism, therefore, for this particular defect, from the evidence found by microscopic examination of a cross-section of the enamel piece is as follows:

The ferric oxide that is formed during the first part of the firing reacts with the iron carbide, forming carbon monoxide at pressures greater than one atmosphere. This causes the very large bubbles in the enamel. These bubbles break and thus let a fresh supply of oxygen come in contact with the iron carbide to form more carbon monoxide. This process will continue either until all of the enamel is fired off or the oxygen has reacted with all of the carbide. Usually the enamel is fired too hard before the latter takes place. If the sample is removed from the furnace and allowed to cool to room temperature or slightly above, the ferric oxide which is in contact with the carbide or with metallic iron is reduced to ferrous oxide, which will not react with the carbide to form carbon monoxide at temperatures below 1800°F. Therefore, the enamel will smooth down and the cover coats can be applied without difficulty after a second firing of the ground coat.

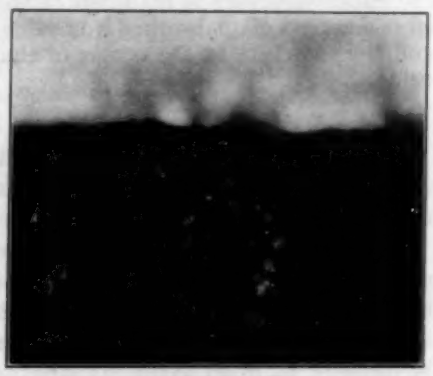


FIG. 7.—500×.

**(3) Formation of Bubbles in Enamel**

Microscopic examination of samples of iron coated with the same composition of enamel, the same weight of enamel, and varied only in the

[4] This is an illustration of what Lord and Rueckel (see footnote 2, p. 389) have called illusions. In Fig. 6 the enamel is out of focus and the base metal is in focus, while in Fig. 7 the enamel is in focus and the base metal is out of focus. These photomicrographs are some of the first that were taken and, by following the technique described in this paper, this condition has been largely eliminated.

firing time, show that a short time of firing (about $1^1/_2$ minutes) results in the formation of very few bubbles, and that these bubbles are very small and fairly uniformly distributed. (See Fig. 8.) It may also be noted that there is an almost continuous layer of undissolved iron oxide at the interface.

If another similar sample prepared in the same manner is fired three minutes (see Fig. 9) it is found that the bubbles are much larger and that the cross-sectional area of the bubbles in Fig. 8 is several times greater. Some free iron oxide may be seen at the interface, but not nearly as much

FIG. 8.—500×.

FIG. 9.—500×.

as in Fig. 8. Here there is a hazy layer at the interface caused by the solution of the iron oxide into the enamel; it may also be noted that none of the bubbles is completely surrounded by this hazy layer.

If this experiment be continued it may be found that at $4^1/_2$ minutes practically all of the iron oxide has gone into the enamel, that the hazy layer is much wider, and that the bubble size is larger but the number of bubbles is less. (See Fig. 10.) Finally, at about seven minutes the bubbles have practically all disappeared and the hazy layer extends almost to the surface. (See Fig. 11.)

Samples exhibiting large amounts of undissolved iron oxide at the interface fishscale readily and these samples have poor adherence. Again, on samples that "shiner-scale" it is invariably found that the hazy layer extends almost (and in some cases entirely) to the surface of the enamel.

From this it may be concluded that at least one of the causes of fish-scaling is underfiring or undissolved iron oxide at the interface, and that "shiner-scales" are caused by the hazy layer coming too close to the surface of the enamel.

From the photomicrographs it will be seen that the hazy layer can

FIG. 10.—500×.

FIG. 11.—500×.

readily be followed by the use of the microscope. When the samples are overfired, the hazy layer extends to the surface

## VII. Summary

(1) Considerable progress has been made in the development of the technique of polishing and examining microscopically samples of enameled iron.

(2) The speed of the polishing disks and the type of abrasive used affect very materially the flatness of field that is obtained visually in the microscope eyepiece or on the ground glass of the camera.

(3) The use of decentered critical illumination adds materially to the amount of fine detail that can be observed. This detail is necessary for progress in the studies of enamels.

AMERICAN ROLLING MILL COMPANY
MIDDLETOWN, OHIO

# CLARION CLAY OF VINTON COUNTY, OHIO*

By Wilber Stout

ABSTRACT

The Clarion clay in the Hope field of Vinton county is persistent over a large area, has excellent thickness, and has good mining conditions. It is a high-grade clay approaching semiflint in character and has special adaptation for dry-press and stiff-mud fire brick of cone 31 quality.

## I. Introduction

The name Clarion was first applied geologically by H. D. Rogers, in 1858, to a coal bed that outcrops along the Clarion River in Pennsylvania.[1] The underlying clay soon received the same designation.

**(1) In Pennsylvania** The Clarion horizon in Pennsylvania bears the great deposits of the Clearfield district consisting of plastic clay, several varieties of hard flint clay, burley clay, and diaspore.

**(2) In Maryland** The Clarion clay of the Mount Savage district, used for refractories since 1841, consists of flint clay and a plastic clay of excellent quality.

**(3) In West Virginia** In the Appalachian geosyncline in the Panhandle area of West Virginia this clay is a siliceous plastic clay of moderate heat-resisting ability, not utilized to any great extent.

**(4) In Eastern Ohio** In Eastern Ohio the Clarion member is well developed and persistent in southern Columbiana and northern Jefferson counties. The deposits are usually made up of siliceous plastic clay but in a few places they contain large lenses of excellent plastic clay and irregular masses of flint clay.

**(5) In Southern Ohio** Throughout central Ohio the member is absent save for small and widely scattered deposits of little ceramic worth, but it appears again with fair continuity in southern Ohio in Vinton, Jackson, and Lawrence counties. In general it is accompanied by the Clarion coal with minable thickness. In Lawrence County the clay is quite variable in thickness ranging from 1 to 12 feet. In the better fields the measurements are from 6 to 10 feet.

In general the material is quite siliceous and in places it is decidedly so, approaching a clay-bonded sandstone in composition. In southern Jackson County the Clarion clay is both thin and siliceous but in the northern part it changes decidedly in a small field near Lincoln Furnace in northern Milton Township where the stratum is from 6 to 12 feet in thickness and

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[1] H. D. Rogers, First Geological Survey of Pennsylvania, Vol. II, pp. 475–90.

the material is a plastic clay with low bonding power, select purity, and high refractoriness.

## II. Hope Field

**(1) Brown Township** In the Hope field, including nearly all of Brown Township, the bed is persistent, regular, and thick. The only exceptions are in the western tier of sections where some wants, thin spots, and mined-out tracts are present.

The total area of Clarion clay in Brown Township is nearly 29 square miles. Of this, not less than 25 square miles may be considered as potentially productive. The main part of the field lies on Sandy Run and its tributaries, along Raccoon Creek in the southern part of the township, and on Twomile Run in the northern part. Throughout this basin the clay maintains the high standard necessary for successful industrial development.

**(2) Madison Township** Clarion clay is found in the northeastern part of Madison Township but it is much impoverished south of Zaleski along Raccoon and Wheelabout creeks. There is indication of an extension of good clay eastward into Waterloo Township, Athens County.

**(3) Starr Township** To the north in Starr Township, Hocking County, the Clarion member is thinner and more patchy in distribution and in general is less reliable in quality.

**(4) Thickness of Deposits** In the Hope field proper in Brown Township the Clarion clay seldom falls below 5 feet in thickness and in places expands to as much as 12 feet. The average measurement, from many sections scattered throughout the area, is close to 7 feet.

Normally the member is composed of three rather distinct varieties of clay, differing considerably as to physical and chemical properties.

**(5) Basal Portion Siliceous Plastic** The basal portion of the bed is a light plastic clay, slightly to very siliceous in character, and more or less micaceous. In general this material is a good clean, moderately siliceous clay. It changes downward into a clay-bonded sandstone and upward into the more aluminous plastic clay.

The mean thickness of this part of the member is 3 feet 3 inches. The variations, however, are from 1 foot 6 inches to 4 feet 4 inches.

**(6) Middle Portion Aluminous Plastic** The middle portion of the Clarion member is a high aluminous plastic material commonly referred to by the miners as "cream" clay. Although the bonding power is somewhat limited, it is about right for ease in working through machines and dies. The content of free silica, mica, and common impurities is uniformly too low to be damaging in effect.

The mean thickness of the "cream" clay in the Hope field in Brown Township is 3 feet 4 inches and its variation is from 1 foot 10 inches to 7 feet 2 inches.

**(7) Upper Portion Flint Clay** In most of the Hope field the clay in the upper part tends toward a soft flint clay. It has the composition and the fineness of grain of the true flint clays but not the density or hardness. It develops a limited plasticity. This flinty clay is usually distinct from the plastic below in that it is more highly colored, the shade being dark gray or nearly black. The clay is low in impurities except for that just below the coal which locally contains some pyrite distributed along root impressions.

The usual range in thickness is between 4 inches and 1 foot 6 inches and the mean measurement close to 9 inches. It is a refractory material fitted for high-heat duty service.

**(8) Roof over Clay** The winning of the Clarion clay in the Hope field must be largely by drift mining. The roof is Clarion coal which, with few exceptions, is without parting, is of the blocky type, and varies in thickness from 1 inch to 2 feet 3 inches, averaging 1 foot 1 inch. The coal forms a good roof as the stratum is not easily broken and as it prevents the air from "cutting" the overlying shales.

The important feature of the roof, however, is the character and thickness of the shale which lies above the coal and which forms the real support for drift mining. This shale is carbonaceous, somewhat platy and fissile, resistant to weathering, has a rather high breaking strength, and averages close to 5 feet in thickness.

These shales are locally overlaid by the Scrubgrass coal, above which come shales and sandstones.

The roof of the Clarion clay in the Hope field is thus strong and safe and should allow a high yield of clay.

**(9) Drainage** Near New Plymouth, in the northwestern corner of Brown Township, the Clarion clay lies at an elevation of approximately 880 feet or over 120 feet above the valley plains. On Twomile Run it passes under covering in the southeastern part of Section 24 at 800 feet above tide. In the southwestern corner of Brown Township, Section 31, its elevation is around 835 feet. The dip of the bed eastward along Raccoon Creek is such that the clay finally disappears below the flood plains near Moonville in the central part of Section 7, near the 690-foot level. In a northwest-southeast direction across the field, or from New Plymouth to Moonville, the Clarion member descends from 900 to 690 feet, thus giving it an average dip of 29.3 feet per mile.

No structural features are evident throughout the field.

The dip is uniformly to the east and to the south, the former being more than twice the latter. For economy in haulage and for ease in drainage,

drift mines in the Hope field could be planned to take advantage of the natural slope of the bed.

**(10) Geological Features** The geological features of the Clarion clay in the Hope field are somewhat abnormal compared to those in Jackson, Gallia, Scioto, and Lawrence counties. The differences include changes in the thickness and the structure of the associated Clarion coal, the appearance in the Hope area of the Scrubgrass coal with several feet of carbonaceous shale, the expansion northward of the Clarion-Vanport and the Clarion-Lower Kittanning intervals, and the absence in Brown Township of the Vanport limestone, its place being taken by sandstone.

In the Hope field the Clarion clay lies, on the average, about 54 feet below the Lower Kittanning coal, over 88 feet below the well-developed Middle Kittanning coal, and nearly 57 feet above the Brookville coal with its associated fossiliferous Putnam Hill limestone. On the whole the succession and intervals of separation are quite uniform.

The changes of most importance are those which take place laterally within the clay bed. In a short distance along the borders of the field, the stratum may be altered from a thick deposit of excellent clay to a thin layer of very siliceous material. On account of such rapid transitions careful prospecting is necessary to define clearly the productive areas. Within the basin, however, the clay is uniform both as to thickness and as to quality.

## III. Detail Description of Hope Field

**(1) Sections No. 553 and No. 693** Along Raccoon Creek in central Section 7, just below the former site of Coe's Mill, on the land of A. E. Kennard, the Clarion clay outcrops about 10 feet above water level. The deposit was sampled in May, 1925. The following data are typical of the geological strata in the Hope area.

SECTIONS NO. 553 AND NO. 693

| | | Ft. | In. |
|---|---|---|---|
| Shale, dark | | 5 | 0 |
| Coal, bony, Scrubgrass | | | 8 |
| Shale, black, carbonaceous, fissile | | 6 | 1 |
| Coal, blocky, Clarion | | 1 | 1 |
| Clay, dark, flinty, sampled | Clarion | | 6 |
| Clay, light, plastic, very pure, sampled | | 2 | 8 |
| Clay, light, plastic, very siliceous, sampled | | 1 | 4 |
| Clay, light, plastic, siliceous, sampled | | 1 | 3 |
| Clay, light, plastic, very siliceous, sampled | | | 11 |
| Sandstone, argillaceous | | | 6 |
| Shale and covered | | 7 | 0 |
| Water level, Raccoon Creek | | | |

The deposit contains no apparent impurities such as sandstone layers, ferruginous concretions, pyrite masses, or gypsum crystals. As is com-

monly the case, the lower part of the stratum is siliceous and slightly micaceous in character. The general properties of the Clarion clay on the A. E. Kennard property are shown in the following tests:[2]

**(a) Physical Tests** Working properties: plastic properties of this clay are such that it works well in the machine. Drying behavior: dries satisfactorily in any type of drier. Drying linear shrinkage: 3.5%.

FIRING BEHAVIOR

| Heat treatment (Cone No.) | Linear shrinkage (%) | Volume absorption (%) | Color |
|---|---|---|---|
| 07 | 1.5 | 16.0 | Pink buff |
| 04 | 3.7 | 11.8 | Pink buff |
| 02 | 4.2 | 11.4 | Pink buff |
| 1 | 4.6 | 10.5 | Pink buff |
| 3 | 4.9 | 9.5 | Buff |
| 5 | 5.1 | 8.8 | Buff |
| 7 | 5.8 | 6.5 | Buff |
| 9 | 6.5 | 3.2 | Gray buff |
| 11 | 6.3 | 3.3 | Gray buff |

Overfiring heat treatment: above cone 11 (above 1350°C or 2462°F).

Best apparent firing range: cones 3 to 11 (1190–1350°C or 2174–2462°F); steel-hard at cone 3.

Total linear shrinkage at cone 7: 10%.

Deformation temperature: slightly below cone 29 (about 1650°C or 3002°F).

Possibilities: intermediate heat-duty refractory ware, face brick, sewer pipe, fireproofing, and terra cotta.

**(2) Sections No. 391 and No. 537** South of Hope Station on the property of Jesse White, the Clarion clay has excellent development where exposed in a ravine near his house.

**(a) Physical Tests** Working properties: clay plastic and smooth textured; machines well except for a few laminations which may be remedied by addition of siliceous clay from the lower part of the deposit.

Drying behavior: clay dries with perfect safety under any of the conditions ordinarily employed in drying such products.

Drying linear shrinkage: 4.0%.

FIRING BEHAVIOR

| Heat treatment (Cone No.) | Linear shrinkage (%) | Volume absorption (%) | Color |
|---|---|---|---|
| 07 | 2.8 | 16.25 | Light buff |
| 04 | 4.8 | 10.50 | Light buff |
| 02 | 5.5 | 7.90 | Light buff |
| 1 | 6.2 | 6.08 | Medium buff |
| 3 | 6.4 | 6.04 | Medium buff |
| 5 | 7.0 | 5.72 | Medium buff |
| 7 | 7.0 | 2.65 | Light gray buff |
| 9 | 7.2 | 2.58 | Light gray buff |
| 11 | 7.4 | 2.60 | Gray buff |

[2] For chemical analysis see page 406.

Overfiring heat treatment: above cone 11 (above 1350°C or 2462°F).
Best apparent firing range: cone 02 to above cone 11 (1110 to above 1350°C or 2030 to above 2462°F).
Total linear shrinkage at cone 7: 11.0%.
Deformation temperature: slightly less than cone 31 (1685°C or 3065°F).
Possibilities: intermediate heat-duty refractory ware, face brick, hollow block, fireproofing, sewer pipe, and terra cotta; long firing range and good clear color.

The elevation of the member in this locality is close to 740 feet which is about 50 feet above the valley floor. Exposures on the Betz and Dunn properties to the west also indicate that the Clarion clay maintains excellent continuity, thickness, and quality. Another plant site is present in this area. The advantages here are sufficient room for large works, freedom from flooding, abundance of high-grade clay, proximity of clay to works, and favorable conditions for drift mining.

**(3) Section No. 700** At Hope Station the Clarion clay is regularly mined for the trade by drifting by the Hope Fire Clay Company of McArthur. A sample was carefully cut of each particular part of the member and was analyzed by John L. Carruthers of the Ohio State University.

The entire bed, 8 feet 3 inches, was also sampled and analyzed as sample No. 4. In this mine the flint clay varies from 8 inches to 2 feet or more but averages about as shown above. The thicker bodies are only lenses, quite local in distribution. In kind it should be classed as a soft flint clay since it slakes with a grainy fracture, develops little bonding strength on working, and its chemical and heat-resisting properties tend in that direction. The upper division of the plastic clay or the "creamy" part expands from 1 foot 6 inches to 4 feet 6 inches in thickness. The usual measurement, however, is not far from 3 feet. This clay maintains high purity throughout the mine. The siliceous clay, or basal portion of the deposit, is fine in texture, has slightly more plasticity than the "creamy" clay, and, aside from free silica, contains little detrimental matter. It is a good siliceous material. The associated Clarion coal with the overlying black shale forms a satisfactory roof for drift mining.[3]

Sample No. 1: flint clay, 1 foot 3 inches, upper part of deposit, P.C.E. value 31.
Sample No. 2: aluminous plastic clay, 3 feet, middle part of deposit, P.C.E. value 32.
Sample No. 3: siliceous plastic clay, 4 feet, lower part of deposit, P.C.E. value 26.
Sample No. 4: entire clay deposit, 8 feet 3 inches thick, P.C.E. value 31.

**(4) Sections No. 307 and No. 684** The field of Clarion clay along Sandy Run and its tributaries in the central part of Brown Township is worthy of careful attention as the conditions are es-

[3] Analyses of the separate kinds of clay are given on page 406.

pecially favorable for large ceramic operations. The clay has good continuity, thickness, uniformity, and purity and occurs in such quantities as to sustain major works or even batteries of plants. Mining conditions are excellent, the roof everywhere being a hard fissile shale on which massive sandstone is superimposed. Further, coal for manufacturing the clay into ware may be obtained from the Middle Kittanning member lying about 90 feet higher in the geological column and averaging nearly 3 feet of clean coal.

In Hope Hollow, one and one-fourth miles northwest of Hope Furnace, the member outcrops on the east bank of the stream on the land of G. P. Drayer. Its elevation is close to 780 feet. The clay and related strata are shown in the following record.

**(a) Physical Tests** Working properties: clay plastic, smooth textured, and fine grained; laminates but little in the machine.

Drying behavior: ware from this clay dries safely in any standard type drier.

Drying linear shrinkage: 4.0%.

FIRING BEHAVIOR

| Heat treatment (Cone No.) | Linear shrinkage (%) | Volume absorption (%) | Color |
|---|---|---|---|
| 07 | 1.5 | 16.2 | Pink buff |
| 04 | 3.5 | 11.9 | Pink buff |
| 02 | 4.3 | 11.0 | Pink buff |
| 1 | 4.8 | 9.6 | Light buff |
| 3 | 5.3 | 7.5 | Light buff |
| 5 | 5.8 | 7.2 | Buff |
| 7 | 6.3 | 5.0 | Buff |
| 9 | 6.8 | 2.9 | Gray buff |
| 11 | 7.1 | 2.8 | Gray buff |

Overfiring temperature: above cone 11 (above 1350°C or 2462°F).

Best apparent firing range: cones 1 to 11 (1150 to 1350°C or 2102 to 2462°F); steel-hard at cone 1.

Total linear shrinkage at cone 7: 10.3%.

Deformation temperature: slightly below cone 29 (slightly below 1650°C or 3002°F).

Possibilities: intermediate heat-duty refractory ware, face brick, sewer pipe, fireproofing, and terra cotta. The firing range is long and the color is a clear buff, free from specks.

**(5) Sections No. 550 and No. 691a** Along Raccoon Creek in the vicinity of Hope Furnace the Clarion clay lies close to the level of the flood plain. It disappears below drainage about one-fourth mile east of the old stack. The best exposure is at the base of the hill north of the stream and about one-eighth of a mile northwest of the furnace. A composite section at this place is given.

SECTIONS NO. 550 AND NO. 691A

| | | Ft. | In. |
|---|---|---|---|
| Sandstone, massive | | 43 | 0 |
| Shale, dark | | | 5 |
| Coal, bony | Middle Kittanning | | 5 |
| Clay shale, carbonaceous | | | 3 |
| Coal, good | | 2 | 4 |
| Clay shale | | | 1 |
| Coal, good | | | 5 |
| Clay, siliceous, impure | | 3 | 6 |
| Shales, gray, siliceous | | 19 | 8 |
| Clay, dark, shaly | Oak Hill | 1 | 6 |
| Coal smut and dark clay | | | 2 |
| Clay, dark gray, impure | | 5 | 4 |
| Clay, very ferruginous | | 1 | 0 |
| Shale, gray | | 9 | 8 |
| Coal, weathered, Lower Kittanning | Lower Kittanning | 1 | 5 |
| Clay, plastic, light, fair | | 3 | 6 |
| Clay, plastic, light, siliceous | | 2 | 3 |
| Sandstone, massive, soft, micaceous | | 53 | 6 |
| Covered | | 2 | 0 |
| Shale, dark, carbonaceous | | 3 | 3 |
| Coal, weathered, Clarion | | 1 | 2 |
| Clay, flinty, dark, good | Clarion | 1 | 2 |
| Clay, plastic, light, excellent | | 7 | 2 |
| Clay, plastic, light, very siliceous | | 1 | 6 |

In the above section the stratigraphic relations of the Clarion member to others higher in the column are well shown. In this part of the field the Middle Kittanning coal has so thickened that it may be mined in a large way for a fuel supply. As shown by analyses the quality of the coal is quite good. Near Hope Furnace the Clarion clay lies nearly 730 feet above tide. The member bears an exceptional thickness of "cream" clay, which, however, may be only local in distribution. The area offers a large volume of high-grade material for industrial operations.

**(6) Section No. 695** Along the road about one-half mile south of Hope Furnace, on the land of George P. Drayer, the Clarion clay was faced to a depth of 8 feet or more and about 130 pounds of material were taken from top to bottom. The sample is representative of that near the surface and should closely approximate that under deep covering.

**(a) Physical Tests** Working properties: clay smooth and plastic with high bonding power; laminates slightly in auger machines.

Drying behavior: easily and safely dried by any of the methods commonly employed.

Drying linear shrinkage: 3.7%.

Overfiring temperature: above cone 11 (above 1350°C or 2462°F).

Best apparent firing range: cones 1 to 11 (1150 to 1350°C or 2102 to 2462°F); steel-hard at cone 1.

Total linear shrinkage at cone 7: 10.0%.

Deformation temperature: slightly below cone 29 (or slightly below 1650°C or 3002°F).

FIRING BEHAVIOR

| Heat treatment (Cone No.) | Linear shrinkage (%) | Volume absorption (%) | Color |
|---|---|---|---|
| 07 | 1.5 | 15.2 | Pink buff |
| 04 | 4.3 | 9.2 | Light buff |
| 02 | 4.3 | 9.8 | Light buff |
| 1 | 5.1 | 8.2 | Light buff |
| 3 | 5.8 | 6.2 | Buff |
| 5 | 5.8 | 5.4 | Buff |
| 7 | 6.3 | 3.0 | Gray buff |
| 9 | 6.8 | 1.8 | Gray buff |
| 11 | 6.8 | 0.2 | Gray buff |

Possibilities: intermediate heat-duty refractory ware, face brick, fireproofing, sewer pipe, and terra cotta; fires to good clear color.

In its extension eastward the Clarion clay dips rapidly but in King Hollow in Section 3 it may be reached at a depth approximating 90 feet. Much the same conditions also exist along Hewett Fork from Mineral to Carbondale in Waterloo Township, Athens County.

**(7) Sections No. 256 and No. 538** Along Sandy Run northeast of Hope Furnace for a distance of nearly two miles the Clarion clay lies at or only a few feet below the flood plain as shown by the frequent appearance of the carbonaceous shale and the Clarion coal. At the picnic ground near the southern boundary of Section 11, on land of the Ohio Mineral Company, the Clarion clay appears for a short distance where the stream has eroded the eastern bank to some depth. Where channeled, the clay was solid and the sample is therefore representative of the material under deep cover.

**(a) Physical Tests** Working properties: clay plastic, smooth, and works well through the dies of the machine without development of objectionable cracks or laminations.

Drying behavior: ware dries well in any type of drier.

Drying linear shrinkage: 3.5%.

FIRING BEHAVIOR

| Heat treatment (Cone No.) | Linear shrinkage (%) | Volume absorption (%) | Color |
|---|---|---|---|
| 07 | 1.3 | 14.05 | Light buff |
| 04 | 2.0 | 12.40 | Light buff |
| 02 | 3.4 | 10.04 | Light buff |
| 1 | 3.7 | 9.38 | Light buff |
| 3 | 4.0 | 7.32 | Light buff |
| 5 | 4.5 | 7.14 | Light buff |
| 7 | 5.0 | 5.46 | Light gray buff |
| 9 | 5.5 | 3.64 | Light gray buff |
| 11 | 5.5 | 1.61 | Gray buff |

Overfiring temperature: cone 1 (1350°C or 2462°F).

Best apparent firing range: cones 02 to 11 (1110 to 1350°C or 2030 to 2462°F).

Total linear shrinkage at cone 7: 8.5%.

Deformation temperature: cone 30 (1670°C or 3038°F).

Possibilities: intermediate heat-duty refractory ware, face brick, hollow block, fireproofing, and sewer pipe.

The plastic properties of the Clarion clay are not high but the bonding strength is all that is necessary for ease in working through machines and dies. The column is smooth and has few defects such as cracks and laminations. The green ware dries safely in any of the common types of driers now in commercial use. The average drying shrinkage is 3.74% and the firing shrinkage 6.22%. From these, the total shrinkage is 9.96% or 1.2 inches per foot. Further, the physical properties of the Clarion clay fit it especially well for dry-press work. The powdered material, under the action of the press, compacts firmly and densely without shearing.

CHEMICAL ANALYSES

| Section No. | 553 693 | 391 537 | 700 No. 1 | 700 No. 2 | 700 No. 3 | 700 No. 4 | 307 684 | 695 | 256 538 |
|---|---|---|---|---|---|---|---|---|---|
| Loss at 105°C | 1.32 | 0.92 | | | | | 1.22 | 1.94 | 0.89 |
| Ignition loss | 8.69 | 8.73 | 10.93 | 11.03 | 6.42 | 8.13 | 8.02 | 8.65 | 8.02 |
| Silica ($SiO_2$) | 55.90 | 54.29 | 45.87 | 46.07 | 63.34 | 54.19 | 56.89 | 54.21 | 57.73 |
| Alumina ($Al_2O_3$) | 28.05 | 29.37 | 35.74 | 35.72 | 23.32 | 30.24 | 27.28 | 28.13 | 27.19 |
| Ferric oxide ($Fe_2O_3$) | 1.87 | 1.98 | 1.94 | 1.34 | 1.66 | 1.38 | 1.75 | 2.29 | 1.69 |
| Lime (CaO) | Trace | 0.08 | 0.29 | 0.15 | 0.04 | 0.27 | Trace | Trace | 0.08 |
| Magnesia (MgO) | 0.53 | 0.52 | 0.66 | 0.66 | 0.97 | 0.68 | 0.62 | 0.55 | 0.53 |
| Titanium ($TiO_2$) | 1.72 | 1.07 | 0.83 | 1.43 | 0.90 | 1.27 | 1.52 | 1.98 | 1.20 |
| Phosphorus ($P_2O_5$) | 0.02 | 0.05 | 0.14 | 0.29 | 0.05 | 0.27 | 0.01 | 0.01 | 0.04 |
| Sodium ($Na_2O$) | 0.55 | 0.66 | 0.51 | 0.48 | 0.39 | 0.39 | 0.37 | 0.21 | 0.32 |
| Potassium ($K_2O$) | 1.62 | 2.29 | 1.05 | 1.37 | 2.34 | 2.02 | 2.45 | 2.14 | 2.44 |
| Sulphur (S) | 0.017 | 0.04 | | | | | 0.006 | 0.004 | 0.23 |
| Total carbon (C) | 0.26 | 0.20 | | | | | 0.17 | 0.17 | 0.16 |
| Inorganic carbon (C) | 0.06 | 0.00 | | | | | 0.07 | 0.01 | 0.00 |

OXIDE MOLECULAR RATIO

| Sample | | $K_2O$ | $Na_2O$ | CaO | MgO | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2$ | $TiO_2$ | $P_2O_5$ | Total RO | P.C.E. value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. E. Kennard | 553 | 0.058 | 0.019 | 0.000 | 0.019 | 0.067 | 1.0 | 1.993 | 0.061 | 0.001 | 0.163 | 29 |
| Jesse White | 391 | 0.078 | 0.022 | 0.003 | 0.018 | 0.061 | 1.0 | 1.848 | 0.036 | 0.002 | 0.182 | 31 |
| G. P. Drayer | 307 | 0.090 | 0.013 | 0.000 | 0.023 | 0.064 | 1.0 | 2.085 | 0.056 | 0.000 | 0.190 | 29 |
| G. P. Drayer | 695 | 0.076 | 0.007 | 0.000 | 0.020 | 0.081 | 1.0 | 1.927 | 0.071 | 0.000 | 0.184 | 29 |
| Ohio Mineral Co. | 256 | 0.090 | 0.012 | 0.003 | 0.019 | 0.062 | 1.0 | 2.123 | 0.044 | 0.001 | 0.186 | 30 |

## IV. Conclusions

The Clarion clay has a long firing range, averaging nearly ten cones. It becomes steel-hard at cone 3 and reaches good maturity at cone 8. The fired ware is relatively free from warping, dishing, and checking defects and also from blisters, pimples, and scums. The ware fires to a clear buff color, with good finish and appearance.

The possibilities of the Clarion clay in the Hope field of Vinton County are excellent for the material has merit and usefulness, especially for refractory products.

Such a base of supply of high-grade material is adequate for wide and extensive ceramic interests. The field is large in size, has good mining conditions, is accessible to transportation, has satisfactory labor nearby, and is supplied with fuel and electrical power. The field is important and well worth careful consideration for those interested in refractory products.

GEOLOGICAL SURVEY OF OHIO
COLUMBUS, OHIO

# CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. PURDY, Editor

ABSTRACTERS: A. ALLY, C. R. AMBERG, A. A. AYARS, R. BARTA, L. T. BROWNMILLER, E. C. CLEMENS, W. M. COHN, R. H. EWELL, M. A. EWER, J. L. GALLUP, C. G. HARMAN, R. A. HEINDL, E. B. HEWITT, H. INSLEY, S. KONDO, M. V. KONDOIDY, K. LARE-HOROVITZ, W. LERCH, T. N. MCVAY, W. W. MEYER, R. G. MILLS, S. I. PEREAL, E. P. REXFORD, D. E. SHARP, G. R. SHELTON, H. H. STEPHENSON, J. G. TOLPIN, E. J. VACHUSKA, H. F. VIEWEG, M. J. G. WESTFELDT, A. E. R. WESTMAN, W. C. O. WHITE.

Vol. 11 July, 1932 No. 7

## Abrasives

**Rapid progress in precision cylindrical grinding.** R. E. W. HARRISON. *Can. Machinery*, **40** [15], 35–39 (1929).—With the growing use of the centerless grinder, the degree of precision of cylindrical grinding machines has increased. The metal removal capacity is low compared with that of the lathe, but it is still capable of considerable increase. The centerless grinder tends to eliminate deformation of work due to wheel thrust; it can be put into use at once on full power, and the time required for the closing cycle is less than in the centered type on account of increased rigidity. Improved grinding wheels have increased output. The applications of different methods of grinding are discussed and their respective limitations indicated. (*J.I.M.*)

**Abrasive wheel and its applications.** W. R. GUTTERIDGE. *Trans. Junior Inst. Eng.*, **41**, 164–79 (1931).—In grinding there are two main branches, precision and off-hand or stock removal, which are in turn subdivided into about thirty smaller groups, principally differentiated by the type of machine in use. Hand grinding is not dealt with. In precision grinding the chief factors are the class of wheel to be used, the surface speeds of the work and of the wheel, and the traverse of the wheel and the work. Cylindrical, universal, and surface grinding machines are considered. In the last section a few safety suggestions and devices are mentioned. (*J.I.M.*)

**Grinding of metals and refractories.** H. W. WAGNER. *Metals & Alloys*, **2**, 39–43 (1931).—The manufacture of grinding wheels of Alundum and Carborundum is briefly described and some account is given of their use in grinding metal castings. Grinding refractory brick is recommended instead of chipping, so as to obtain the correct shape and a true fit with the minimum of cement between the brick, thus prolonging the life of the furnace. (*J.I.M.*)

**Modern roll grinding.** N. LEERBERG. *Rolling Mill Jour.*, **5**, 323–26 (May, 1931).—L. discusses the design, construction, and operating principles of roll grinders. (*J.I.S.I.*)

**Danger to health from grindstone dust with special reference to artificial stones and silicosis.** V. MENSLAGE. *Zentr. Gewerbehyg. Unfallverhütung*, **18**, 123–25 (1931). (*C.A.*)

### CIRCULARS

**Abrasive and industrial diamonds.** P. M. TYLER. Bur. Mines *Information Circ.*, No. 6562, 25 pp. (Free.)—T. describes types of industrial diamonds and discusses their occurrence, mining, production, uses, and marketing. A list of dealers and users is appended. R.A.H.

**Pumice and pumicite.** PAUL HATMAKER. Bur. Mines *Information Circ.*, No. 6560, 23 pp. (Free.)—H. discusses properties, uses, occurrence, mining, both domestic and foreign deposits, markets, and prices of pumice and pumicite. R.A.H.

### PATENTS

**Grinding irregular shafts.** K. L. HERRMANN (Bantam Ball Bearing Co.). U. S. 1,854,934, April 19, 1932.

[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.
The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

**Grinding compound.** R. S. McCLAUGHRY (Standard Oil Co.). U. S. 1,855,195, April 26, 1932.

**Dressing fixture.** JOHN EDGAR (Barber-Colman Co.). U. S. 1,855,343, April 26, 1932.

**Lapping machine.** F. O. HOAGLAND AND A. L. WILDER (Pratt & Whitney Co.). U. S. 1,855,631, April 26, 1932.

**Truing mechanism for grinding machines.** H. M. ALLISON (John Bath). U. S. 1,856,180, May 3, 1932.

**Grinding machine.** W. J. GUILD (Heald Machine Co.). U. S. 1,856,185, May 3, 1932. J. D. SCAIFE (Heald Machine Co.). U. S. 1,856,227, May 3, 1932. C. C. GIBSON (Two Way Electric Grinder Co.). U. S. 1,856,808, May 3, 1932. VIKTOR JERECZEK. U. S. 1,857,549, May 10, 1932. H. A. SILVEN (Norton Co.). U. S. 1,858,222, May 10, 1932.

**Abrasive disk.** A. J. DOERMANN (Titan Abrasives Co., Inc.). U. S. 1,856,321, May 3, 1932.

**Abrasive article.** E. B. WYATT (Minnesota Mining & Mfg. Co.). U. S. 1,857,340, May 10, 1932.

**Process and apparatus for coating.** R. P. CARLTON (Minnesota Mining & Mfg. Co.). U. S. 1,856,744, May 3, 1932.

**Dressing grinders.** A. L. DE LEEUW (co-assignor, A. F. Nathan). U. S. 1,857,142, May 10, 1932.

**Abrasive wheels.** CARBORUNDUM CO., LTD. (R. C. Benner and W. G. Soley). Brit. 369,634, April 6, 1932.

**Grinding and polishing devices.** M. CASTELLS. Brit. 370,269, April 13, 1932.

**Machines for grinding teeth of gear wheels, etc.** GEAR GRINDING CO., LTD., AND J. W. SNARRY. Brit. 371,151, April 27, 1932.

**Abrading tools.** G. F. TAYLOR (British Thomson-Houston Co.). Brit. 349,732, April 23, 1929. A tool formed with diamond particles embedded in a sintered composition of W carbide and Co may be mounted in a carbon block with Mo rods. (*C.A.*)

**Abrasive compound.** M. SPIRA AND A. CANTER. Belg. 378,103, April 30, 1931. The compound consists of $S_2Cl_2$, MgO, colza oil, silicon carbide, emery powder, and glass powder. (*C.A.*)

**Self-bonding corundum crystals.** EARL L. HAUMAN (Exolon Co.). Can. 315,670, Sept. 29, 1931. Euhedral crystals of $\alpha$-corundum dispersed in a glassy matrix within which they are developed are fired to bond the crystals together for use as an abrasive or for refractory purposes. The firing range is modified by the addition of metal oxides of an earthy nature, *e.g.*, tin oxide, borax, etc. (*C.A.*)

**Abrading or polishing tools.** BAKELITE G.M.B.H. Ger. 541,374, March 9, 1924. Granular abrasives are mixed with about 10% of a fusible phenol-aldehyde resin containing practically no free phenol and capable of being hardened. About 4% of a high-boiling aldehyde, *e.g.*, furfurol, is incorporated into the mixture which is then molded under pressure in the cold. (*C.A.*)

## Art and Archaeology

**Quality production.** RICHARD F. BACH. *Bull. Amer. Ceram. Soc.*, **11** [6], 149–52 (1932).

**Importance of good design in chinaware.** G. S. STONE. *Bull. Amer. Ceram. Soc.*, **11** [6], 153–54 (1932).

**Trends of the New York buying public.** RUTH CANFIELD. *Bull. Amer. Ceram. Soc.*, **11** [6], 154–56 (1932).

**Lead-zinc-titanium crystal glaze.** SEIJI KONDO. *Jour. Jap. Ceram. Assn.*, **38** [449], 263–71 (1930).—This article deals with the results of a further study of titanium crystal glaze. Six frits of the formula, $0.5PbO\ 0.5RO\ 0.1Al_2O_3\ xSiO_2$ (R = Ca, Zn, $K_2$; $x$ = 1.5, 2.0, or 2.5), were mixed with various amounts of CuO, NiO, $CoCO_3$, $Fe_2O_3$, $MnO_2$, $U_3O_8$, kaolin, silica, and rutile, and the glazes were applied on convex disks of biscuited porcelain. They were then fired to cones 6*a* or 10. *Group 1.* Among 3 series of the glazes with $0.1Fe_2O_3$ and $0.3TiO_2$, excellent or satisfactory results were obtained with $2.0SiO_2$. The glazes rich in ZnO usually crystallized well, while those containing much CaO were poor in this property. Beautiful crystals were formed more in the lime-rich glazes than in the zinc-rich. The results of the other 2 groups are also given.

S.K.

**Experiments with Persian glazes.** ERNST HINRICHS. *Keram. Rund.*, **39** [13], 186–87 (1931).—A glaze containing PbO, BaO, $K_2O$, $Na_2O$, $Al_2O_3$, $SiO_2$, and $B_2O_3$ in the frit flaked off when fired at cone 05 when all the $K_2O$ was added as nitrate. When two-thirds of the $K_2O$ was added as feldspar and one-third as nitrate this trouble was eliminated and a satisfactory glaze was obtained. Compositions of several colored glazes are given. H.I.

**Earthenware underglaze colors.** WILHELM BACHER. *Keram. Rund.*, **39** [15], 218 (1931).—Elementary directions and precautions in the use and application of underglaze colors are given. H.I.

**Fritted glaze for round kiln firing.** ERNST HINRICHS. *Keram. Rund.*, **39**, 110–11 (1931).—Three fritted glazes for use on faience fired in a downdraft kiln at cones 08 to 05 are described. H.I.

**Decalcomania on bisque-fired and unfired earthenware.** G. PULIESO. *Keram. Rund.*, **39** [18], 260–63 (1931).—General directions for the application of decalcomania to unfired and bisque-fired earthenware are given. The tendency of the decoration to scale off after firing is shown to be dependent on the fineness of grinding of the body, the composition of the body, the temperature of firing, and the porosity. H.I.

**Decorations used by the Pennsylvania Germans.** FELIX PAYANT. *Design*, **33** [10], 248 (1932).—Henry C. Mercer began the manufacture of tile in Doylestown, Pa. The designs were floral, largely tulip, with many Biblical scenes. Stiegel glass was enameled in colors. Illustrated. E.B.H.

**Tulip ware, Pennsylvania-German ceramics.** CARLTON ATHERTON. *Design*, **33** [10], 245–47 (1932).—Tulip ware is of Pa.-German origin in the 17th and 18th Centuries. It was of red clay decorated with cream slip, and graffito and slip painting were employed. The slip painting was done by means of a slip cup having inserted near its base from one to seven quills through which the slip was allowed to trickle in patterns. The glaze was usually yellow, transparent, or translucent. The primitive potter's wheel and the disk cutter are described. Illustrated. E.B.H.

**Ceramics by New York craftsmen.** ANON. *Amer. Mag. Art*, **24** [4], 307 (1932).—The Syracuse Museum of Fine Arts, May, 1931, exhibited the work of New York State potters exclusively, in memory of Mrs. Robineau (see *Ceram. Abs.*, **9** [4], 252 (1930)). E.B.H.

**The de Forest Collection of folk pottery.** MARION THRING. *Amer. Mag. Art*, **24** [4], 300 (1932).—Mrs. Robert de Forest has given to the Pennsylvania Museum an extensive collection of folk pottery including 5000 pieces from 40 countries. E.B.H.

**New York on Staffordshire ware.** ANON. *Connoisseur*, **89** [367], 213–14 (1932).—The Museum of the City of New York exhibited an assembly of pitchers, plates, etc., showing New York views only. Illustrated. E.B.H.

**Pottery.** ANON. *Christian Sci. Mon.*, **24** [48], 6 (1932).—Some of the novel shapes and designs, together with new colors such as "damask rose," are described. Illustrated. E.J.V.

**From the native potter's wheel.** ANON. *Interior Arch. and Dec.*, pp. 280–81 (Dec., 1931). (*D.I.*)

**Tradition and experiment in potteries.** JOSEPH BURTON. *Design Ind. Assn. Quarterly Jour.*, pp. 12–13 (Jan., 1932); for abstract see *Ceram. Abs.*, **10** [8], 582 (1931). (*D.I.*)

**Pottery management for artistic products.** ANON. *Keram. Rund.*, **39** [16], 232–34 (1931).—The minimum requirements in machinery, kilns, buildings, etc., for art potteries of different sizes are given. H.I.

**French art.** WALDEMAR GEORGE. *London Studio* [Atelier], **103**, 3–32 (1932). H.H.S.

**Aert Schouman's glasses.** W. A. THORPE. *Connoisseur*, **89** [368], 266–67 (1932).—Schouman was a versatile Dutch artist who did glass stippling, a process perfected by Frans Greenwood. The subjects were usually fruit or portraits. E.B.H.

**Ikora glassware.** HANS HILDEBRANDT. *Kunst*, pp. 68–75 (Dec., 1931). (*D.I.*)

**Bottles.** ROY SHELDON. *Advertising & Selling*, pp. 30–34 (Nov., 1931). (*D.I.*)

**Glass products of Württemberg factories.** HANS HILDEBRANDT. *Deut. Kunst & Dek.*, pp. 182–86 (Dec., 1931). (*D.I.*)

**Lobmeyr glassware.** WOLFGANG BORN. *Deut. Kunst & Dek.*, pp. 228–34 (Jan., 1932). (*D.I.*)

**Enamelware by Friederich Veit of Vienna.** H. A. VON KLEEHOVEN. *Deut. Kunst & Dek.*, pp. 176–80 (Dec., 1931). (*D.I.*)

**Light as advertising.** ALFRED SALMONY. *Commercial Art*, pp. 240–48 (Dec., 1931); see also *Ceram. Abs.*, **10** [11], 751 (1931). (*D.I.*)

**Backgrounds for modern bathrooms.** ANON. *House & Garden*, pp. 60–61 (March, 1932). (*D.I.*)

**Mixtec discoveries at Monte Alban, Mexico.** ALFONSO CASO. *Illus. London News*, **180**, 217 (1932).—The tomb of ten Mixtec Caciques found at Monte Alban, near Oaxaca, has yielded results which are regarded as most significant. H.H.S.

**Exhibition of Indian tribal arts.** BLANCHE NAYLOR. *Design*, **34** [1], 17–21 (1932).—The College Art Assn. is sponsoring a traveling exhibition of Indian tribal arts including some examples of pottery unlike the commercialized variety usually seen. The itinerary is given. E.B.H.

**Battersea enamels.** W. B. HONEY. *Connoisseur*, **89**, 82–89 (1932).—Examination of the municipal rate-books of Battersea reveals that the factory lasted only 3 years, 1753 to 1756, the first occupants being Jansen, Delamain, and Brooks. Illustrations of genuine Battersea are given. H.H.S.

**Dresden china.** LAURA LORENSON. *Arts & Dec.*, **35** [6], 16 (1932).—Failing to turn base metal into gold, Johann Bottger, a Berlin chemist, in 1707 produced a red stoneware resembling Chinese boccaro and in 1709, a white porcelain made possible by the discovery in Saxony of kaolin. The factory at Dresden was later moved to Meissen. The period up to 1735 was known as the period of painting, presided over by Johann Herold, who often divided the decoration of single pieces among several special artists. Later he was overshadowed by Johann Kandler, the sculptor, who recognized the suitability of porcelain for the statuettes and groups associated with the name Meissen (Dresden, Saxony). The famous Swan Service, a table service complete for 100 persons was made in his period. Porcelain flowers were important items. Kandler was followed by Acier from Paris in 1764. The lace figures belong to this period. Many original patterns and models are being reproduced today and Bottger is honored wherever porcelain is known. E.B.H.

**Age of Walnut.** C. REGINALD GRUNDY. *Connoisseur*, **89** [367], 195–99 (1932).—The Age of Walnut, embracing reigns of Charles II, James II, William and Mary, and Anne, not an era of great art, was one of superb craftsmanship. English potters and glassmakers acquired technical skill which was unrivaled in Europe. Illustrated. E.B.H.

**Treasures from Viking graves.** ANON. *Illus. London News*, **180**, 192–93 (1932).—Viking relics of 600 A.D. found at Valsgärde have been investigated by the Univ. of Upsala. H.H.S.

**Clay plastics of the Gothic period in Leipzig.** ALB. SCHRÖDER. *Keram. Rund.*, **39** [15], 219–20 (1931).—Examples of clay figurines of this period are given. H.I.

**Discoveries in Egypt about 3000 B.C.** ALAN ROWE. *Illus. London News*, **179**, 740–42 (1931).—The results of the 1930–1931 season of the E. B. Coxe, Jr., expedition, Univ. of Pennsylvania, at the mastaba of Ra-Hotep are recorded. Illustrated. H.H.S.

**Sasanian palaces at Kish.** STEPHEN LANGDON. *Illus. London News*, **180**, 273 (1932).—Churches, palaces, swimming pools, etc., have been unearthed at Kish. See also *Ceram. Abs.*, **10** [10], 678 (1931). H.H.S.

**Ithaca excavations.** W. A. HEURTLEY. *Illus. London News*, **180**, 276–77 (1932).—The British School is "excavating" at Ithaca under water of a submerged cave floor containing Mycenean vases. 9 photos. H.H.S.

**Dogs in Chinese pottery.** KITTY RITSON. *Illus. London News*, **180**, 286–87 (1932).—Glazed pottery of the Han, Wei, and T'ang dynasties in the Royal Ontario Museum, Toronto, is illustrated. H.H.S.

**Sale of K'ang-hsi bottles.** ANON. *Nat. Glass Budget*, **47** [52], 7 (1932).—Two rare, peach bloom, chrysanthemum bottles with pale red glazes were sold for $8500 to Yamanaka & Co. from the Tin-Ying collection at the American Art-Anderson Galleries. Both were K'ang-hsi pieces about 8 in. high. E.P.R.

**Chinese pottery in Herbert Coleman's collection.** W. A. THORPE. *Connoisseur*, **89** [368], 246–53 (1932).—The pottery is described and illustrated. E.B.H.

**Discovery of the site of Kenzan's kiln.** JUNSEI KASUGA. *Jour. Jap. Ceram. Assn.*, **38** [445], 41–43 (1930).—K. unearthed an ancient kiln in the grounds of the temple Hozoji near Kioto in 1928–1929, and found several perfect vessels with the mark of Kenzan Ogata who was one of the three famous potters in the Genroku period. Illustrated. S.K.

PATENTS

**Shade or reflector.** A. F. HORN (Macbeth-Evans Glass Co.). U. S. 86,774, April 19, 1932.

**Design for pitcher, etc.** O. C. NOBLE (Tygart Valley Glass Co.). U. S. 86,802, April 19, 1932.

**Design for combined bathtub and basin.** J. E. DRUCKENMILLER. U. S. 86,829, April 26, 1932.

**Design for bathtub.** GEORGE SAKIER (Standard Sanitary Mfg. Co.). U. S. 86,935 and 86,936, May 10, 1932.

**Design for soap dish.** A. C. HIRSCH. U. S. 86,837, April 26, 1932.

**Design for cooking stove.** J. F. LEE (Hardwick Stove Co.). U. S. 86,779 and 86,780, April 19, 1932.

**Design for range.** A. E. FELLNER (Roesch Enamel Range Co.). U. S. 86,834, April 26, 1932. HENRY LANGE. U. S. 86,847, April 26, 1932.

**Design for bottle.** G. N. MAS. U. S. 86,849 and 86,850, April 26, 1932.

**Design for plate, etc.** A. H. NICHOLSON AND VERNON NICHOLSON. U. S. 86,927, May 10, 1932.

**Design for jar, etc.** O. C. NOBLE (Tygart Valley Glass Co.). U. S. 86,928, May 10, 1932.

**Glazing powdered aluminum on china.** YONOKITI HIRAI. Japan. 91,381, May 12, 1931. Figures are drawn or painted on china with raw japan on which powdered Al is sprinkled, and the china is heated at 500 to 600° for 1.5 to 2 hr. (*C.A.*)

## Cements

**Synthesis of calcium silicates at temperatures below 1400°C.** SEIJI KONDO AND CHIHIRO KAWASHIMA. *Jour. Jap. Ceram. Assn.*, **38** [455], 711–14 (1930).—Chemically pure calcium carbonate and silica were mixed in the molar proportions of 1:1, 3:2, 2:1, and 3:1, and the mixtures were heated at temperatures ranging from 1000 to 1400°C for 60, 50, or 30 min. The products were analyzed for free lime and silica. The results show that the rate of formation of dicalcium silicate is very large for all mixtures. The curves for the range of 1300 to 1400°, however, indicate that pure 1:1, 3:2, and 3:1 silicates should be produced if the corresponding mixtures were heated stronger. S.K.

**Synthesis of caicium aluminates.** SEIJI KONDO AND CHIHIRO KAWASHIMA. *Jour. Jap. Ceram. Assn.*, **38** [454], 627–30 (1930).—Chemically pure calcium carbonate and alumina were mixed in the molar proportions of 3:5, 1:1, 5:3, and 3:1 and the mixtures were heated at temperatures ranging from 1000 to 1500°C for 1 or ½ hr. The products were analyzed for free lime and alumina, and the percentages and molar ratios of combined lime and alumina were calculated. The products of 3:5 and 1:1 mixtures consisted mainly of 1:1 compounds for all temperatures. A 5:3 mixture produced a 1:1 compound at about 1100° and completed the reaction at 1450° forming a 5:3 compound. A 3:1 mixture produced a 1:1 compound at about 1100°, changed into a 5:3 compound at about 1350°, and seemed to complete the reaction at 1500° to form a 3:1 compound. S.K.

**Study of calcium aluminates. I. Synthesis.** SEIJI KONDO AND TOSHIYOSHI YAMAUCHI. *Jour. Jap. Ceram. Assn.*, **40** [470], 81–87 (1932).—Continuation of the 1st report by S. Kondo and Chihiro Kawashima, see preceeding abstract. Summary: (1) The mixtures of calcium carbonate and alumina in the molecular ratios of 3:1, 5:3, 1:1, and 3:5 were heated at 1200 to 1700°C for 1 to 7 hr. The products were analyzed for free lime and free alumina. The effect of heating temperature and time on the combination of lime and alumina and on the ratios of the 2 combined oxides was sought. (2) A large number of experiments were carried out on Rathke's method of determining free lime, and the process of dissolving free lime was improved. In the process, the mixture of glycerine and the sample were heated at 75° for 25 min. under constant shaking; then it stood at 75° for 1 hr. (3) Practically pure 3:1, 5:3, and 1:1 aluminates were obtained by heating the mixtures for 2 hr. at 1540, 1450, and 1600°C., respectively. Only 99% pure 3:5 aluminate (the remaining 1% being alumina) was obtained by heating the mixture for 2 hr. at 1700°C. **II. Microstructure.** *Ibid.*, **40** [470], 87–91 (1932).—Experiments have been made of the microstructure and *n* of the 4 practically or almost pure calcium aluminates devitrified at 1300°C or at temperatures a little lower than melting point. The processes of formation of the aluminates have been traced by the observation of those samples in which the chemical combination was

incomplete. *Conclusions:* (1) The results of experiments on the microstructure and $n$ of the pure aluminates agree well with those reported by Rankin and Wright in 1915–1916. (*a*) The authors, however, obtained $n_{D\omega} = 1.621$ for $3CaO{\cdot}5Al_2O_3$ instead of 1.617 given by R. and W. (*b*) The results of $5CaO{\cdot}3Al_2O_3$ are different from those given by R. and W. No isotropic crystal was found, all crystals being biaxial and optically negative. More than 2 weeks were required to obtain the ground crystals free from glass. $n_D$: $\alpha = 1.665$, $\beta = 1.660$, $\gamma = 1.645$, and $\gamma - \alpha = 0.020$. $n$ of the glass: $n_D = 1.612$, and $n_F - n_C = 0.017$. (2) The determination of optical properties of the immatured samples was almost impossible, but the general tendencies of the processes of the chemical combination are given. S.K.

**Change of crystals in Portland cement clinker caused by melting.** KATSUZO KOYANAGI. *Jour. Jap. Ceram. Assn.*, **38** [455], 715–17 (1930).—Melting of clinker makes alite dissociate into dicalcium silicate and lime. The melt is quick setting and weak. S.K.

**Dusting of Portland cement clinker.** KATSUZO KOYANAGI. *Jour. Jap. Ceram. Assn.*, **38** [456], 803–809 (1930).—A study was made of the cause of the dusting with the following results: (1) Dusting occurs within a wide range of its composition. There are, however, nearly definite proportions among its constituents. (2) The amount of lime in dusting clinker is always lower than that in dicalcium silicate. With an increase in the proportions of ferric oxide and alumina, the proportion of lime is lowered and the time required for dusting is prolonged. (3) Dusting occurs only when another substance enters into the raw mixture. A siliceous substance is more effective than an aluminous. (4) The most probable cause is from siliceous lining brick. See also *Ceram. Abs.*, **10** [2], 97 (1931). S.K.

**Minerals in Kühl clinkers and iron cements.** KATSUZO KOYANAGI. *Jour. Jap. Ceram. Assn.*, **38** [454], 623–26 (1930).—K. investigated the minerals contained in clinkers of Kühl and iron cements which had been prepared with a rotary test kiln. It is probable that alumina favors the formation of alite. The iron cement, consisting mainly of belite and colorless transparent crystals of dicalcium silicate, is fairly strong, *i.e.*, cements poor in alite may be fairly strong. The chief rôle of alite is probably in the early strength of cements. S.K.

**Corrosion of cement.** A. DUEBEL. *Z. angew. Chem.*, **44** [28], 589–90 (1931); *Chim. & ind.*, **27** [1], 110 (1932).—The mechanism of corrosion is due to the attack of salts on the uncombined lime formed from calcium silicates during hardening. M.V.K.

**Determining setting of cement by means of electric current.** G. BAIRE. *Ind. chimique*, **18** [213], 700 (1931).—As the cement sets the conductivity decreases. M.V.K.

**Methods to determine free lime in cements.** H. RATHKE. *Zement*, **20** [28], 651–56 (1931); *Chim. & ind.*, **27** [1], 109–10 (1932).—The use of tartaric acid or benzoic acid instead of ammonium acetate is rapid. None of these methods, however, can be applied for determining free lime in hydrated substances with the exception of calcareous sandstone. Calcium hydroxide dissolves slowly in the glycerin and the water eliminated during the reaction produces wide errors. The calorimetric method of Bessey (*Ceram. Abs.*, **10** [3], 172 (1931)) gives better results in this case. M.V.K.

**Ciment fondu and its properties.** PAVLOVSKI. *Mines, Carrières, Grandes Entreprises* (May, 1931); *Ind. chimique*, **18** [215], 884 (1931).—Ciment fondu or aluminous cement properties are described. M.V.K.

**Determination of lime in relation to the properties of cement.** V. SEVIERI. *Ann. chim. applicata*, **21**, 545–52 (1931).—From considerations of analytical data the new formula $CaO - [\text{free } CaO + 0.75 \times (2Al_2O_3 + Fe_2O_3 + Mn_2O_3 + SO_3)]$:soluble $SiO_2 \geqslant 3$, is considered most suitable for the evaluation of Portland cement of high basicity. (*B.C.A.*)

## PATENTS

**Making a cement composition.** S. G. SEATON (Utica Hydraulic Cement Co.). U. S. 1,855,271, April 26, 1932.

**Making Portland cement.** H. H. STEINOUR (Riverside Cement Co.). U. S. 1,856,442, May 3, 1932. The method of making Portland cement which comprises first calcining material containing lime, silica, alumina, and iron oxide, in which the proportion of lime is in excess of that which will combine, even on repeated calcining, with the silica, alumina, and iron oxide contained therein, permitting the resultant product to cool, grinding the product and mixing therewith material containing sufficient silica, alumina, and iron oxide to combine with the excess lime, and recalcining the mixture.

**Making cement.** GEORGE LYNN (Pittsburgh Plate Glass Co.). U. S. 1,857,205, May 10, 1932. A hydraulic cement formed by mixing with a high alumina cement and water a small amount of calcium chloride.

## Enamels

**Study of the relative viscosity of enamel glasses.** C. J. KINZIE. *Jour. Amer. Ceram. Soc.*, **15** [6], 357–60 (1932).

**Mechanism of black speck formation in enamel resulting from reboiling of the ground coat.** ANSON HAYES, J. J. CANFIELD, AND G. W. MCGOHAN. *Jour. Amer. Ceram. Soc.*, **15** [6], 338–44 (1932).

**Discussion on "A mechanism of black speck formation in enamel resulting from reboiling of the ground coat."** ROBERT B. SCHAAL AND DONALD H. FULLER. *Jour. Amer. Ceram. Soc.*, **15** [6], 344–51 (1932).

**Reply to discussion of Schaal and Fuller.** ANSON HAYES, J. J. CANFIELD, AND G. W. MCGOHAN. *Jour. Amer. Ceram. Soc.*, **15** [6], 351–53 (1932).

**Fishscales in sheet enamels.** VIELHABER. *Sprechsaal*, **65** [12], 223 (1932); *Emaillewaren-Ind.*, **9** [12], 91–96 (1932).—Systematic investigation of fishscales is made difficult because they are classified into many groups. Fishscales sometimes appear after cooling the ground fired piece or during drying after the first coating when the object is slowly heated. They may also appear after the third and fourth firing (decoration bubbles) or even several months later on an enameled object. The secondary reason for their appearance seems to be clear. There must be interior tensions which produce these scales. For the primary reason, all possible causes have been suggested, *viz.*, melting, grinding, pickling, kilns, etc. Investigations show that fishscales appear often in enamels with a nickel ground; droplets of the metal, identified as nickel sulphide, were found in a melting kiln. According to V., however, the fishscales had nothing to do with the nickel sulphide found. It is important to note that they can be produced on the object when cold by using hydrochloric or sulphuric acid; these scales appear on the outer side of the object after several days. When some pickle is added to the acid, these defects appear only after the heating of the enameled object. It must be assumed that the real reason for the appearance of fishscales is connected with the absorption of hydrogen by the sheet metal. It was found that hydrogen develops pressures up to 70 atmospheres. The property of absorbing hydrogen varies with different sheet metals. Often during pickling some parts of the object are well pickled while other parts not enough, and the over-pickled parts of the object have fishscales after enameling. This fact shows that hydrogen is the cause of fishscales. Additions of raw materials to the mill counteract the formation of fishscales because of the greater melting interval resulting and the fact that the enamel surface remains open for a longer time so that the hydrogen can escape. The same result is attained by slow firing at lower temperatures. The pickling itself plays an important rôle, but the pickling time and concentration of the acid can not be regulated exactly. The sensitiveness to pickling of different metal sheets depends on their chemical composition, structure, and shape, although nothing exact can be said about it. Numerous typical examples of the appearance of fishscales are discussed. M.V.K.

**Investigation of enamels by means of chemical analyses.** W. KERSTAN. *Keram. Rund.*, **39** [9], 127–29 (1931).—Known methods of analysis of enamels for $F_2$, $SiO_2$, $Sb_2O_3$, $Sb_2O_5$, $Al_2O_3$, $Fe_2O_3$, and ZnO are described in a form which is suitable for plant analyses. H.I.

**Technique of vitreous enameling.** J. E. HANSEN. *Sheet Metal Ind.* [London], **5** [8], 557; [9], 635 (1931–32); *Sprechsaal*, **65** [13], 41–42 (1932).—Clear, white, and colored enamels are discussed. See *Ceram. Abs.*, **11** [6], 350 (1932). M.V.K.

**Quality enamels.** H. LANG. *Keram. Rund.*, **39** [16], 234–35 (1931).—In enameling thick sheets a "harder" enamel must be used than for thin ones. Hard enamels have high softening points. They can be obtained by adding quartz or quartz and clay to batches for softer enamels. H.I.

**Enamel.** ANON. *Metallurgique française*, **17**, No. 193 (1932); *Emaillewaren-Ind.*, **9** [14], 114 (1932).—The preparation of enamels and different methods used for enameling are described. M.V.K.

**Cleansing sheet metal objects before enameling.** J. E. HANSEN. *Brit. Ind. Finishing* [London], **2** [11], 148; [20], 170–74 (1931); *Emaillewaren-Ind.*, **9** [13], 102 (1932). M.V.K.

**Enameling steel and cast-iron kiln parts.** W. R. SAMUEL. *Ind. Finishing Mag.*, **4** [2], 71–80 (1929); *Emaillewaren-Ind.*, **9** [14], 109–10 (1932).—S. describes in detail the cleaning, pickling, spraying, immersing, drying, firing, and decorating of steel and iron parts. M.V.K.

**Vitreous enameling and firing on conveyers under definite control.** ANON. *Iron Age*, **127**, 1584–90 (May 14, 1931); for abstract see *Ceram. Abs.*, **10** [3], 178 (1931). (*J.I.S.I.*)

**Enameling mechanized on counter-flow principle.** W. O. OWEN. *Iron Age*, **128**, 16–17 (July 2, 1931); for abstract see *Ceram. Abs.*, **10** [11], 758 (1931). (*J.I.S.I.*)

**Refractory alloys.** ANON. *Ind. chimique*, **18** [212], 678 (1931).—The Heraeus Vacuumschmelze A.-G. of Hanau, Germany, produces a new refractory alloy for high temperatures, called "chromav." This alloy was found to be especially advantageous in enamel ovens. Its durability is 200 times greater than that of the iron usually used, and it is 30 to 50 times lighter. M.V.K.

**Impact resistance tests on enameled ware.** K. BEYERLEIN. *Keram. Rund.*, **38**, 774–77 (Dec. 18, 1930).—B. describes various testing methods (the hammer and the falling steel ball types) for determining the impact resistance of enamel coatings and discusses the results obtained. The coating on enameled cast iron breaks down slowly under repeated impact, but that on enameled steel sheet breaks suddenly into fragments after a given number of blows. The method in which a number of balls is allowed to fall on the test piece is more a test of the hardness than of the impact resistance. (*J.I.S.I.*)

**Vitreous enamel impact machine.** H. H. HOLSCHER. *Jour. Amer. Ceram. Soc.*, **15** [6], 353–57 (1932).

**Equipment for the cleaning of metal. XVI.** R. W. MITCHELL. *Metal Cleaning & Finishing*, **4** [4], 207–14 (1932).—Construction features of metal washing machines and characteristics of various cleaners are discussed. Illustrated. For Part XV see *Ceram. Abs.*, **11** [6], 349 (1932). E.J.V.

**Apparatus for working sheet metal and manner of treating drawn objects.** P. GLASER. *Glashütte*, **62** [3], 40–41; [4], 60–61; [5], 77; [11], 184–85; [12], 199–201; [13], 219–20 (1932); *Emaillewaren-Ind.*, **9** [14], 112 (1932).—Machines used for drawing sheet metal objects are described. M.V.K.

**Making the most of the furnace.** VIELHABER. *Emaillewaren-Ind.*, **9** [15], 120 (1932).—The best ways of inserting different enameled objects for firing are discussed. M.V.K.

**Continuous enameling furnace and drier.** W. C. KERNAHAN. *Heat Treating & Forging*, **17**, 699 (July, 1931).—The equipment and operations of the plant of the Cribben and Sexton Co., Chicago, Ill., are described. (*J.I.S.I.*)

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**Enameling furnace.** ROBERT MACDOUGALL (Beemack Furnace Co.). U. S. 1,857,206, May 10, 1932.

**Coating metals by spraying.** BRITISH THOMSON-HOUSTON CO., LTD. (General Electric Co.). Brit. 369,943, April 13, 1932.

**Emulsified enamel.** GON'ITI TIKAUTI. Japan. 90,971, April 8, 1931. Pb molybdate is used as the emulsifying material. The enamel consists, *e.g.*, of $Pb_3O_4$ 50, $SiO_2$ 35, $NaNO_3$ 10, and Pb molybdate 10 parts; it melts at about 750°. (*C.A.*)

## Glass[1]

**Strength of strain-free and uniformly strained glasses.** OSCAR KNAPP. *Keram. Rund.*, **39** [16], 230–32 (1931).—Modern annealing leers with no external heat anneal ware in 80 min. They do not produce strain-free glass but should produce glass uniformly strained from the center. To determine the relative impact strength and resistance to heat shock of strain-free and "equally" strained glasses, rings of equal dimensions were annealed to produce glasses of the two types. These were examined in

[1]ERRATUM: A series of abstracts on "The Fundamentals of Glass Technology," from articles in *Ceramic Industry* have incorrectly listed G. V. McCauley and C. D. Spencer as authors. *Ceramic Industry* is solely responsible for the material in the articles. Dr. McCauley and Dr. Spencer edited the series. For abstracts see *Ceram. Abs.*, **10** [11], 763 (1931); **11** [2], 86; [3], 164; [4], 234; [5], 297 (1932).

a polariscope. For heat shock, test specimens were removed from an oil bath at 150°C and plunged into water at 20°. This process was repeated until failure resulted. For resistance to impact, specimens were centered and struck with a falling spherical weight at increasing heights until rupture occurred. In resistance to heat shock 16 out of 40 of the strain-free specimens failed, while 17 out of 49 of the "equally" strained specimens failed. In impact resistance, specimens of the two types gave about the same average results although the "equally" strained specimens showed a greater divergence from the mean. H.I.

**Specific volumes of some two-component glasses.** S. C. WATERTON. *Jour. Soc. Glass Tech.*, **15** [60], 354–60 (1931).—The study is centered in an empirical equation of Mason designed to establish a relationship between molecular volumes of solutes to solvation and ionization in aqueous solution. The Mason equation may prove a useful tool in studying the constitution of glass, although a larger amount of data must be tested by it. G.R.S.

**Relation between composition and specific gravity of glass. I.** SHIZUTA MORIYASU. *Jour. Jap. Ceram. Assn.*, **38** [456], 795–802 (1930).—M. gives the following formulas for the volume, $V$, of glass composed of 6000 g. $SiO_2$ and $62y$ g. $Na_2O$: $V = 0.3084y$-$Na_2O + 2694$ for $y$ smaller than 50 and $V = 0.3677yNa_2O + 2464$ for $y$ greater than 70. The change of the partial specific volume of soda at $y = 50$ indicates the existence of $Na_2O{\cdot}2SiO_2$. The values of the density moduli agree well with those given by English, Turner, and Baillie when $y$ is smaller than 50, and with those given by Winkelmann and Schott when $y$ is greater than 70. S.K.

**Influence of alumina on the constants of devitrification of soda-lime silicate glasses.** W. MÜLLENSIEFEN AND E. ZSCHIMMER. *Glastech. Ber.*, **9** [5], 280–307 (1931); *Ceramics & Glass*, **7** [9], 54; [10], 10 (1931); *Chim. & ind.*, **27** [1], 113–14 (1932).—Schott was the first to find that by replacing a part of the silica by alumina in ordinary glasses, the glass could be worked much better. When present in large quantities, the opposite effect is produced. The recent researches of Berger, Kitaigorodsky, and Tabata demonstrated that, even in definite proportions, $Al_2O_3$ does not always prevent the crystallization in the plastic intervals which are favorable to the mechanical working. Alumina, however, is highly efficient for soda-calcium glasses of the industrial type. The latter corresponds to the molecular composition $Na_2O$, $CaO$, $6SiO_2$ and, according to Kitaigorodsky, satisfactory results are obtained when replacing 0.2 to 0.4 mol. of CaO by the same quantity of $Al_2O_3$ molecules. Such glasses heated to 1050° for 12 hr. did not show any traces of devitrification. It was also found that the crystallization is induced especially by the surface of the molten glass being in contact with the air or other gases and that the intensity of this inducement depends on the chemical nature of the gas which comes in contact with the surface of the glass. Different batches of soda-lime glasses were prepared in which 1 to 6% $Al_2O_3$ replaced a corresponding quantity of $SiO_2$. To compare the tendency of these glasses to devitrify, the constants of devitrification were determined by means of the Zschimmer-Dietzel apparatus. The constants were (1) the temperature $To$ at which the equilibrium between the crystalline phase and the liquid phase of the glass takes place (this temperature is greatly affected by the increase in viscosity with the cooling of all the system in question); (2) the maximum velocity ($CV$ max.) of the growth of the crystals in microns ($\mu$) per minute; (3) the maximum temperature $T$ corresponding to this velocity. The following crystalline phases were found: ($a$) $SiO_2$ in the state of cristobalite or tridymite; ($b$) $Na_2O$, $3CaO$, $6SiO_2$ or wollastonite ($\beta$-$CaSiO_3$); ($c$) pseudo-wollastonite, $CaSiO_3$, probably $-\alpha$. The practical conclusions are (1) an addition of 1 to 3% $Al_2O_3$ diminishes the devitrification in glasses containing 14% $Na_2O$. With a $Na_2O$ content higher than 16%, the alumina addition is without marked effect. Over 14% of $Na_2O$, in spite of the fact that the maximum velocity ($CV$ max.) diminishes, the $Al_2O_3$ addition is rather without effect because the $To$ of equilibrium considerably increases at the same time and reduces the stage of working of the glass in its devitrification. (2) Three to 4% of $Al_2O_3$ added to glasses with >14% $Na_2O$ produces a clear anti-devitrifying effect. When the quantity of $Na_2O$ is > 16%, the same quantity of alumina is without effect. (3) On the other hand, higher quantities of $Al_2O_3$ accelerate the devitrification in the interval of the temperatures of their working in all glasses investigated. M.V.K.

**Using sodium bisulphate in glass manufacture.** I. I. KITAIGORODSKY AND M. A. TZARITSUIN. *Ceramics & Glass*, **8** [1], 19–22 (1932).—Tests on the use of sodium bisulphate ($NaHSO_4$) instead of soda and sulphate in the production of glass showed (1) sodium sulphate, a waste product of the chemical industry, may be used instead of soda and sulphate; (2) it may be transformed into sulphate by firing it with coal; and

(3) it may also be used without previous working for obtaining glass and silicates, although a larger amount of silica is separated during melting. M.V.K.

**Researches on the use of sodium bisulphate in glass.** A. N. KLYARFELD. *Ceramics & Glass*, **8** [1], 22–23 (1932). M.V.K.

**Reaction between calcium carbonate and silica.** W. MASKILL, G. H. WHITING, AND W. E. S. TURNER. *Engineering*, **133** [3457], 468 (1932); for abstract see *Ceram. Abs.*, **11** [6], 390 (1932). A.A.

**Volatilization from potash lead oxide glasses and its bearing on the corrosion of glassmelting pots.** E. PRESTON AND W. E. S. TURNER. *Engineering*, **133** [3457], 468 (1932); for abstract see *Ceram. Abs.*, **11** [6], 353 (1932). A.A.

**Use of electrochemical by-products in glassmaking.** ALEXANDER SILVERMAN. *Nat. Glass Budget*, **48** [1], 20 (1932); *Amer. Glass Rev.*, **51** [32], 10 (1932).—S. dwelt especially on arsenic, selenium, and tellurium. Arsenious oxide takes oxygen during the early stages of a melt and is a balancing agent in insuring lack of color on the finished glass. Used in reasonable amounts in soda-lime glasses, its effects are beneficial except that glasses may turn yellow under solar radiation. In converting ferrous ion to ferric ion, arsenious oxide facilitates penetration of heat rays into the melt. It facilitates firing in lead glasses, but is objectionable where these must be subjected to subsequent heating as in the lamp work on tubing which may darken. The presence of arsenious acid in chemical glassware is undesirable. From 0.5 to 1.0% of selenium is employed extensively in the manufacture of red zinc glasses under reducing conditions. Less selenium is required for the desired color in potash glasses than in soda glasses. Selenium apparently is as effective in color production as the selenites and is less expensive on the basis of equivalent weights of the element. The black variety is commonly employed. Cadmium sulphide is employed with selenium in practically all the desirable red glasses. Carbon or sulphur is usually employed as a reducing agent in selenium red glasses. Arsenious or antimonious oxides are employed in selenium red glasses and the former is superior. The selenium red color is usually brought out under heat treatment. A number of arseno-sulphur compounds of selenium which range from light red to purplish black are known. Investigations are under way to determine whether these are formed in selenium red glasses or whether the compounds may be utilized directly for the production of the color. Under oxidizing conditions in lime glasses containing potash, and practically free from iron, selenium produces a pink color. In soda-lime glasses the element produces an orange color in the presence of a reducing agent. In lead glasses the element produces an amber color in the presence of niter. Selenium is effectively employed in low concentrations as a decolorizing agent, especially for soda-lime glasses. E.P.R.

**Substitutes in the glass industry.** S. Y. RAF. *Ceramics & Glass*, **8** [1], 33–36 (1932).—Data are discussed on the use of different substitutes for alkalis in the production of glass for lowering the total alkali content in different kinds of glass, and standard specifications for the alkali content of glasses in dependence on the system of furnaces, fuel, and kind of glass manufactured. M.V.K.

**Action of increased quantity of cullet on melting of glass for electric bulbs.** S. CHERNYAK. *Ceramics & Glass*, **8** [1], 23–24 (1932).—Additions of cullet of 5, 10, 15, 20, 25, 35, 45, 55, and 65% of the weight of the batch had no influence on the specific gravity, chemical stability, coefficient of cubic expansion, and chemical analysis of the glass, although the coefficient of expansion was slightly decreased. These results are in agreement with those obtained by M. A. Besborodov (see *Ceram. Abs.*, **10** [11], 762 (1931)). M.V.K.

**Fluoride opacification.** WILHELM BÜSSEM AND W. WEYL. *Sprechsaal*, **65** [13], 240–41 (1932).—Opaque and fluoride glasses were examined optically and röntgenographically (for syntheses see *Ceram. Abs.*, **11** [4], 232 (1932)). The microscopical investigations showed that (1) alumina glass has two kinds of crystalline precipitations: (*a*) finely crystalline ground mass distributed uniformly, isotropic; the refractive index could not be more closely determined; (*b*) skeletons of crystals with a weak double refraction are characteristic for crystallizations of cristobalite in technical glasses. The refractive index of the crystals is smaller than that of the surrounding glass. (2) Zinc glasses are permeated with weakly double-refracted needles with a negative character of the longitudinal zone. The refractive index of the crystals is smaller than that of the glass. (3 and 4) Both glasses show tiny crystal needles with a weak double refraction. (5 and 6) Magnesium and lead glasses have abnormally large cristobalite crystals; they are beam-shaped, have a direct extinction, and are highly segmented. The formation of cracks is probably due to the conversion ($\alpha \longrightarrow \beta$-cristobalite). In the separate glasses, No. 1 especially, a finely crystalline phase is found which could not be more closely

identified. The crystals are isotropic and therefore are probably precipitated fluoride. The optical investigations showed that the glasses contained at least two kinds of crystals whose grain size had two orders of magnitude. The X-ray investigation showed that two systems of lines were to be recognized: one, consisting of coarse punctured lines with the larger crystals, and the second, with homogeneous blackened lines due to the microcrystalline type. The fine crystalline precipitates were recognized as sodium fluoride and the coarse crystalline as cristobalite. The fact that cristobalite and NaF were precipitated as crystalline phases in all glasses which had highly varied compositions shows that conclusions can be drawn about the dispersion of light of the system. One of the chief factors affecting dispersion is the difference in the refractive indices of glass and the crystalline phase. If it is known that the same phase or the similar mixture of crystals separates in wide limits independently of the basic glass, then it is possible to foretell, at least quantitatively, how a varied oxide will act in this direction. Because the refractive index of cristobalite and NaF is smaller than that of the fundamental glass, all the components will further increase the refractive index and also improve the dispersion of light. The measurements of Gehlhoff, Kalsing, and Thomas confirm this fact also (see *Ceram. Abs.*, **10** [10], 683 (1931)). Thus a glass is more strongly opacified with a baryta addition than with additions of MgO, CaO, or SrO. M.V.K.

**Fluorine compounds in the glass industry.** F. Doerinckel. *Glastech. Ber.*, **9** [5], 268–74 (1931); *Chim. & ind.*, **27**, No. 2 (1932); *Chem. Trade Jour.*, **90** [2337], 236 (1932). M.V.K.

**Identification of devitrification products of the soda-lime-silica technical glasses.** A. Dietzel. *Glastech. Ber.*, **9** [5], 307–309 (1931); *Ceramics & Glass*, **7** [9], 47 (1931); *Chim. & ind.*, **27** [1], 113 (1932).—The chemical compounds which crystallize during the devitrification of industrial soda-lime glasses are (1) $SiO_2$-cristobalite $\beta$, tridymite $\gamma$, (2) $CaSiO_3$ wollastonite, (3) pseudo-wollastonite, (4) $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ (1:3:6), (5) quartz $\beta$, (6) $Na_2O{\cdot}2SiO_2$, and (7) $Na_2O{\cdot}2CaO{\cdot}3SiO_2$ (the latter 3 compounds are seldom found). $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ crystals are deposited most often on glasses of the window-glass type when they are left to devitrify in the interval of temperatures slightly below 1000° and up to 1050°. If the same glasses are kept a longer time (12 hr.) at higher temperatures, wollastonite crystals will be deposited. See also *Ceram. Abs.*, **10** [11], 762 (1931). M.V.K.

**Effect of sulphur on a commercial glass containing lead oxide.** J. H. Partridge. *Engineering*, **133** [3457], 468 (1932); for abstract see *Ceram. Abs.*, **11** [6], 353 (1932). A.A.

**Electromelting of glass.** Seiji Kondo and Chihiro Kawashima. *Jour. Jap. Ceram. Assn.*, **40** [470], 72–80 (1932).—A study has been made of the methods of melting various glasses by electric current. In most of the experiments, the current flowed directly through the batch and carbon electrodes were used. *Conclusions:* (1) Those glasses which contain 5% or more of soda or 7% or more of potash were easily melted. A Pyrex glass batch containing 0.61% potash and 3.83% soda after melting did not melt well even with 200 v. current. (2) The electromelted glasses were colored black by the contamination of carbon. An addition of oxidizing agent was useless and produced minute bubbles in the products. (3) The discoloration was perfectly avoided by introducing a few per cent of zinc oxide to the batches. The vapor of zinc escaping from the furnace can be recovered by sublimation. The use of sodium sulphate and red lead is injurious, as they make the glasses turbid by the formation of zinc sulphide and black by the reduction of lead, respectively. (4) Excellent glasses were obtained by the indirect method in which the glass pot was placed in a cryptal furnace. With arc furnaces, melting was difficult and the discoloration was severe. S.K.

**Variability of surface tension of water with increasing thickness of glass plates. Experiments with the Searle tensiometer.** Bishambhar Nath Srivastava. *Kolloid-Z.*, **56**, 45–49 (1931).—It was found in experiments with the Searle tensiometer that the surface tension of the liquids investigated varied directly as the thickness of the glass plates used in the experiment. H.I.

**Variability of surface tension with density and cross-section of glass plate, as measured with the Searle tensiometer.** Satyendra Ray. *Kolloid-Z.*, **56**, 49–51 (1931).—A theory is proposed to account for the phenomena observed in the preceding paper. H.I.

**Positive ion emission from thin platinum films on glass.** R. A. Nelson. *Rev. Sci. Instruments*, **2** [3], 173–79 (1931).—The ionic emission of a platinum plated tube is much greater than that of an unplated tube. An explanation of the result is given as well as the characteristics of curves of electrolysis potential against plate current for sodium and potassium glass. H.I.

**Manufacture of rolled plate. XX.** ERNST LUTZ. *Glass Ind.*, **13** [5], 84–89 (1932).—L. describes some of the experiments and new methods used in manufacturing thin and standard rolled plate glass. Illustrated. For Part XIX see *Ceram. Abs.*, **11** [6], 360 (1932). E.J.V.

**Coloring glass with cadmium sulphide.** GRANGER AND BABILLE. *Ind. chimique*, **18** [213], 700 (1931).—Factors exerting great influence on the successful coloring of glass with cadmium sulphide are (1) composition of the sulphide, (2) its physical state, (3) the nature of the solvent, (4) the temperature of the melting of the glass, and (5) the tank atmosphere. M.V.K.

**Coloring glass. I.** KITSUZO FUWA. *Jour. Jap. Ceram. Assn.*, **38** [446], 71–88 (1930).—The effect of glass composition and auxiliary agents on the color produced by ferric oxide, ferrous oxide, and cobalt oxide and the transmission spectra and curves of visible and ultra-violet rays of the glasses are given. **II.** *Ibid.*, **38** [447], 156–69 (1930).—*NiO:* (1) Oxidizing agents, reducing agents, or arsenious acid do not affect the color. (2) The oxide colors the glasses intensely but absorbs ultra-violet rays markedly. $SnO_2$: (1) Per cent transmission of blue and green is low. (2) The introduction of a small amount of the oxide has no effect on the percentage absorption of ultra-violet rays. S.K.

**Coloration and origin of gold, ruby, and sapphire glass.** B. LANGE. *Chem. Zentr.*, **i**, 2444 (1931); for abstract see *Ceram. Abs.*, **9** [9], 704 (1930). (*B.C.A.*)

**Production and properties of safety glass and its intermediate layer.** E. DIETEL. *Kunststoffe*, **22**, 8–11 (1932).—The difficulties encountered in making safety glass are discussed. The desirability of having some means of measuring such properties as strength, freedom from shattering, etc., is emphasized. See also *Ceram. Abs.*, **11** [2], 94 (1932). (*C.A.*)

**Permeability of glasses to ultra-violet radiations.** P. GILARD, P. SWINGS, AND A. HAUTOT. *Bull. sci. acad. roy. Belg.*, **17**, 362–68 (1931); *Ind. chimique*, **18** [215], 890 (1931); *Sprechsaal*, **65** [14], 259 (1932); for abstract see *Ceram. Abs.*, **11** [2], 96 (1932). M.V.K.

**Ultra-violet and infra-red glasses.** S. ENGLISH. *Brit. Jour. Radiol.*, **4**, 724–27 (1931).—The various types of spectral transmission available in glass are summarized, and the compositions and other characteristics of special absorbing and transmitting glasses are discussed. See also *Ceram. Abs.*, **11** [2], 90 (1932). (*C.A.*)

**Opal glass and its uses for illumination.** G. KÖRRN. *Keram. Rund.*, **39** [10], 144–46; [12], 174–76 (1931).—Individual materials for the manufacture of opal glass are described and their compositions and particular functions in the production of opal glass are given. There are short descriptions of the common methods of making opal glass. See also *Ceram. Abs.*, **10** [2], 106 (1931). H.I.

**Jena glass.** WILHELM WAVENFELD. *Form*, pp. 461–68 (Dec. 15, 1931). (*D.I.*)

**Flow of the glass mass in tanks.** S. G. LIOZNYANSKAYA AND G. Y. ZHUKOVSKI. *Ceramics & Glass*, **8** [1], 14–19 (1932).—A transparent, viscous liquid was used and the direction of flow was observed by means of coloring agents. M.V.K.

**Temperature ratios in tanks of the Fourcault system.** B. F. KUZMICH. *Ceramics & Glass*, **8** [1], 28–32 (1932).—Fourcault tanks must be designed for a definite temperature ratio. Investigations show that the best temperature ratios are obtained when the temperature maximum lies in the center (American data) from the point of view of the glass flow. M.V.K.

**Air displacement principle in Knox-O'Neill feeder.** ANON. *Amer. Glass Rev.*, **51** [29], 11–12 (1932). E.P.R.

**Batching device with lever and photoelectric tube control.** ANON. *Amer. Glass Rev.*, **51** [32], 11–12 (1932). E.P.R.

**Production and use of spun glass.** GEDEON VON PAZSICZKY. *Keram. Rund.*, **39** [17], 244–46 (1931). H.I.

**Glass wallpaper.** ANON. *Amer. Glass Rev.*, **51** [29], 19 (1932); see following abstract. E.P.R.

**Spun glass wallpaper.** ANON. *Arts & Dec.*, **37** [1], 58 (1932).—Glass wallpaper is made by laying tiny threads of glass on a paper surface which is durable and applied as any wallpaper would be. Colors are used effecting a harmonious glowing surface. Illustrated. E.B.H.

**Glass vessels for medicines.** KITSUZO FUWA, MASABUMI SATO, AND FUJIO SUZUKI. *Jour. Jap. Ceram. Assn.*, **38** [450], 320–27 (1930).—Tests were made on the durability, discoloration in flame working, thermal endurance, devitrification, and the opacity to ultra-violet rays of glass vessels for medicines sold on the market or made at the labora-

tory of the Tokio Electric Co. The glass T-10 made in the laboratory gave an excellent result for each test. S.K.

**Installation of mirrors in hotel.** ANON. *Nat. Glass Budget*, **48** [1], 16 (1932). E.P.R.

**Glass blackboards for schools.** NEW YORK SILICATE BOOK SLATE CO. *Glass Ind.*, **13** [5], 95 (1932); see also *Ceram. Abs.*, **10** [2], 112 (1931). E.J.V.

**Interior uses of flat glass.** ANON. *Amer. Glass Rev.*, **51** [29], 20 (1932). E.P.R.

**Progress of the glass industry in 1931.** ANON. *Glashütte*, **62** [8], 126–27 (1932).—The researches are discussed of (1) Gehlhoff, Thomas, and Fritz-Schmidt on the effect of properties of glass-forming oxides on permeability (*Ceram. Abs.*, **10** [12], 829 (1931)); (2) fluoride opacification (*ibid.*, **10** [10], 683 (1931)); (3) the influence of manganese oxide on some properties of glass, investigated by Childs, Dimbleby, Winks, and Turner (*ibid.*, **10** [10], 684 (1931)); and (4) selenium dioxide as a constituent of glasses by Navias and Gallup (*ibid.*, **10** [7], 485 (1931)). M.V.K.

**Progress in glass technology during 1930–1931 under the auspices of the Glass Research Delegacy.** ANON. *Jour. Soc. Glass Tech.*, **15** [60], 347–53 (1931).—The educational and research work of the year is reviewed and a list of publications is given. G.R.S.

**Developments in European glass industry.** MAURICE HOUYET. *Nat. Glass Budget*, **47** [53], 3 (1932).—H. tells of glass silk, glass brick, corrugated glass roofings, mosaics, and other new products. E.P.R.

**Glass in China.** WALTER BUCHLER. *Glass Ind.*, **13** [5], 91–92 (1932).—The use of plate and wire glass in China is increasing. E.J.V.

**Society of Glass Technology meeting.** ANON. *Chem. & Ind.*, **51** [14], 297–98 (1932); *Chem. News*, **144** [3754], 204–206 (1932); *Refrac. Jour.*, **8** [3], 81–90 (1932); *Nat. Glass Budget*, **47** [49], 11–12 (1932).—A review is given of the following papers: (1) Strength of material as affected by discontinuities and surface condition, by F. C. Lea; (2) Investigations on the tensile strength of glass, by E. J. Gooding (*Ceram. Abs.*, **11** [6], 353 (1932)); (3) Structure of sillimanite and related materials, by W. H. Taylor (*ibid.*, **11** [6], 370 (1932)); and (4) Studies in clay mixtures for glassmelting pots. IV. Corrosion resisting properties, by J. H Partridge, E. F. Adams, and J. R. Lait (*ibid.*, **11** [6], 370 (1932)).

BOOKLET

**An Outline of the Technology of Glass.** JAMES S. MORGAN. Abstracted in *Amer. Glass Rev.*, **51** [31], 10 (1932).—The American Potash & Chemical Corp. has compiled extracts on the use of boric oxide in glass manufacture. E.P.R.

PATENTS

**Sheet-glass surfacing means.** J. C. BLAIR. U. S. 1,854,394, April 19, 1932. I. O. PEDERSEN. U. S. 1,854,484, April 19, 1932. E. G. STAHLE. U. S. 1,854,493, April 19, 1932, and 1,856,173, May 3, 1932. (Libbey-Owens-Ford Glass Co.)

**Glass-surfacing apparatus.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,854,507, April 19, 1932. J. M. MCGOLDRICK (Libbey-Owens-Ford Glass Co.). U. S. 1,857,852, May 10, 1932.

**Ornamental glass tile.** EMIL MEDINA. U. S. 1,857,856, May 10, 1932.

**Leer stacker.** E. H. LORENZ (Hartford-Empire Co.). U. S. 1,857,967, May 10, 1932.

**Ware-stacking mechanism.** G. J. GRIZEY (Hartford-Empire Co.). U. S. 1,858,010, May 10, 1932.

**Apparatus for the manufacture of glassware.** L. J. BROCHE (Tropenas Co.). U. S. 1,858,137, May 10, 1932.

**Securing glass sheets upon supporting tables.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,854,399, April 19, 1932.

**Forming glass articles.** AUGUST KADOW (Owens-Illinois Glass Co.). U. S. 1,854,408, April 19, 1932.

**Glassware annealing leer.** A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,854,452, April 19, 1932.

**Glassware handling apparatus.** A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,854,453, April 19, 1932.

**Seal for laminated glass.** G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 1,854,496, April 19, 1932.

**Glassmelting furnace.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,854,505, April 19, 1932.

**Sheet-glass drawing means.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,854,506, April 19, 1932.

**Grinding runner.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,854,508, April 19, 1932.

**Means for mounting plate glass.** J. C. GIPE AND J. P. CROWLEY (Libbey-Owens-Ford Glass Co.). U. S. 1,854,545, April 19, 1932.

**Means for adjusting the thickness of glass plates and sheets.** YVON BRANCART. U. S. 1,854,641, April 19, 1932.

**Making glass articles.** P. J. MESSER. U. S. 1,854,753, April 19, 1932.

**Cutting flat glass.** R. C. WILLIAMSON (Pilkington Bros., Ltd.). U. S. 1,855,078, April 19, 1932.

**Process and apparatus for delivering glass to a leer.** EUGENE GENTIL (American Bicheroux Co.). U. S. 1,855,955, April 26, 1932.

**Glass-cutting apparatus.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,856,128, May 3, 1932.

**Cleaning plate glass polishing runners.** J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,856,129, May 3, 1932.

**Casting rough plate glass.** G. P. DESPRET (Compagnies réunies des glaces et verres spéciaux du nord de la France). U. S. 1,856,278, May 3, 1932.

**Forming hollow glassware.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,856,518, May 3, 1932.

**Making wire glass.** P. F. GUTMANN (Mississippi Glass Co.). U. S. 1,856,630, May 3, 1932.

**Annealing leer.** JULIUS SYLVESTER (Simplex Engineering Co.). U. S. 1,856,668, May 3, 1932.

**Manufacture of silica articles with glazed surface.** GASTON DELPECH (Société Quartz et Silice). U. S. 1,857,080, May 3, 1932.

**Making optical disks.** W. M. POUNDSTONE (Pittsburgh Plate Glass Co.). U. S. 1,857,213, May 10, 1932.

**Forming glass tubing from pressed glass blanks.** K. E. PEILER (Hartford-Empire Co.). U. S. 1,857,257, May 10, 1932.

**Completing pressed blown ware or blown ware.** R. J. BEATTY (Federal Glass Co.). U. S. 1,857,491 and 1,857,492, May 10, 1932.

**Manufacturing hollow glass bodies by pressing and blowing.** J. J. C. HARDENBERG (L. A. Nypels). U. S. 1,857,540, May 10, 1932.

**Glass-cutting machine.** J. E. WALKER (Clymer Mfg. Co.). U. S. 1,857,748, May 10, 1932.

**Forming glass tubing from glass billets.** K. E. PEILER (Hartford-Empire Co.). U. S. 1,857,791, May 10, 1932.

**Glass-forming apparatus.** CARROLL CONE (Libbey-Owens-Ford Glass Co.). U. S. 1,857,806, May 10, 1932.

**Brush holder.** H. N. DIEDERICHS (Libbey-Owens-Ford Glass Co.). U. S. 1,857,808, May 10, 1932.

**Producing sheet glass.** J. L. DRAKE AND L. C. MAMBOURG (Libbey-Owens-Ford Glass Co.). U. S. 1,857,809, May 10, 1932.

**Glassware.** BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD., AND T. WARDLEY. Brit. 369,555, April 6, 1932.

**Glass articles.** GENERAL ELECTRIC CO., LTD., AND R. L. BREADNER. Brit. 369,722, April 6, 1932.

**Surface treatment of glassware and apparatus for use in connection therewith.** BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD., T. WARDLEY, AND J. B. MURGATROYD. Brit. 369,900, April 13, 1932.

**Laminated materials.** BRITISH THOMSON-HOUSTON CO., LTD. Brit. 370,323, April 13, 1932.

**Compound glass.** RHEINISCH-WESTFALISCHE SPRENGSTOFF AKT.-GES. Brit. 370,958, April 27, 1932.

**Continuous feeding of a chamber outside a glass furnace.** SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Brit. 371,190, April 27, 1932.

**Laminated glass.** W. H. MOSS. Can. 317,726, Dec. 1, 1931, 317,919, Dec. 8, 1931, and 318,145, Dec. 15, 1931; see also *Ceram. Abs.*, **11** [1], 26; [6], 363 (1932). See following abstract. (*C.A.*)

**Laminated glass.** CAMILLE DREYFUS AND GEORGE SCHNEIDER. Can. 318,147,

Dec. 15, 1931. Between sheets of glass is interposed a sheet containing cellulose acetate and dibenzyl tartrate as plastifier. (*C.A.*)

**Glass.** CORNING GLASS WORKS. Fr. 38,733, June 26, 1930; addition to Fr. 673,436, April 16, 1929. A heat-absorbing borosilicate glass contains an oxide of a metal of the second group of atomic weight between 60 and 120, *e.g.*, Zn, CoO, and FeO. The ratio of FeO to CoO is between 4 to 1 and 16 to 1. (*C.A.*)

**Apparatus for pouring molten glass.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 38,613, May 31, 1930; addition to 579,444. (*C.A.*)

**Flowing molten glass.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 38,876, June 27, 1930, and 38,911, Aug. 1, 1930; additions to 579,444. (*C.A.*)

**Pot furnace for fusing glass.** GLACERIES DE SAINT-ROCH. Fr. 710,817, Feb. 9, 1931. (*C.A.*)

**Apparatus for cooling sheets of glass.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 710,931, Feb. 9, 1931. (*C.A.*)

**Safety glass.** ROBERT DELLOYE. Fr. 711,134, May 13, 1930. The cooling of safety glass after it has been heated in an autoclave to complete the cementing of its elements is accomplished by injecting into the autoclave a fine mist of water while maintaining the pressure, afterward decreasing this progressively, and then circulating air through the autoclave. See also *Ceram. Abs.*, **11** [2], 104 (1932). (*C.A.*)

**Laminar glass.** ADOLF KÄMPFER AND A. C. PLÖTZE. Fr. 711,755, Feb. 21, 1931. The layers of glass are movable with respect to one another by using a supple intermediate layer or layers, and they differ in their vibrations because of differences in dimensions and, if desired, in composition. (*C.A.*)

**Glass.** SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Fr. 711,976, June 3, 1930. Means for drawing off molten glass from the furnace is described. (*C.A.*)

**Furnace for melting glass.** JENAER GLASWERK SCHOTT & GEN. Fr. 712,362, Feb. 28, 1931. (*C.A.*)

**Glass.** PILKINGTON BROS., LTD. Fr. 712,769, March 7, 1931. Conduits for molten glass are made of a refractory material nonporous to gases, such as fused silica or porcelain. (*C.A.*)

**Glass.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 713,839, March 25, 1931. Means for making, transporting, and cooling sheets of glass are described. See also *Ceram. Abs.*, **11** [6], 365 (1932). (*C.A.*)

**Fusion pots for glass.** CRISTALLERIES DE NANCY. Fr. 713,857, March 25, 1931. (*C.A.*)

**Glassmaking plant.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 713,867, March 26, 1931. (*C.A.*)

**Cooling furnace for sheets of glass.** N.-V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 714,792, April 4, 1931; see also *Ceram. Abs.*, **11** [6], 365 (1932). (*C.A.*)

**Furnaces for annealing glass.** UNITED GLASS BOTTLE MANUFACTURERS, LTD. Fr. 714,926, April 8, 1931. (*C.A.*)

**Apparatus for making reinforced glass.** DUPLATE CORP. Fr. 715,098, April 11, 1931. (*C.A.*)

**Melting glass.** CORNING GLASS WORKS. Fr. 715,466, April 15, 1931. Glass having a high borosilicate content is fused and refined in vessels having a high $Al_2O_3$ content, *e.g.*, of refractory material containing fused $Al_2O_3$ 85, binding clay 8, and kaolin 7%, with or without the addition of phosphoric acid. (*C.A.*)

**Glassmelting furnace.** HARTFORD-EMPIRE CO. Fr. 715,487, April 15, 1931. (*C.A.*)

**Apparatus for making sheets of glass.** CHANCE BROS. & CO., LTD., AND A. L. FORSTER. Fr. 715,635 and 715,636, April 18, 1931. (*C.A.*)

**Composite glass.** I. G. FARBENINDUSTRIE AKT.-GES. Fr. 715,684, April 18, 1931. Sheets of glass are united by the reaction products of polybasic acids or their anhydrides and polyhydric alcohols, with or without the addition of filling agents such as cellulose derivatives. Examples are given. (*C.A.*)

**Composite glass.** F. W. HALLAUER. Fr. 715,914, April 23, 1931. Each of the 2 sheets of glass is covered on one face with a layer having good adherence, *e.g.*, gelatin, white of egg, or glue for leather, and on drying, a coating is applied formed of an adhesive soluble in turpentine oil or $C_6H_6$, such as Canada balsam or resin, and containing a solvent for the gelatin, etc., layer, such as AcOH. An adhesive coating is also applied to the intermediate layer of celluloid, etc. The superposition of the 3 layers takes

place in a bath of liquid dissolving the adhesive but not the celluloid, *e.g.*, $C_6H_6$ or a plastifying agent. (*C.A.*)

**Glass.** MARIANNE WELLMANN. Ger. 537,633, July 2, 1930. A tough, easily worked Li Be borate glass suitable for the windows of Röntgen ray tubes is manufactured by fusing together $Li_2CO_3$ 4.3, $BeCO_3$ 1.4, and $H_3BO_3$ 18.5 parts. (*C.A.*)

**Colored glass coating.** GLASHÜTTENWERKE VORM. J. SCHREIBER & NEFFEN. Ger. 537,634, Oct. 6, 1929. Colored coatings or patterns are produced on glass by firing metal compounds such as Cu compounds on sulphide glass. Thus, sulphide glass is made by fusing sand, soda, potash, CuO, $Na_2B_4O_7$, and $Fe_2S_3$. A colored effect is produced on this glass by firing thereon a mixture of CuO, $CuSO_4$, and glaze powder. (*C.A.*)

**Trough furnace for melting glass.** HARTFORD-EMPIRE CO. Ger. 539,846, Dec. 13, 1929. (*C.A.*)

**Apparatus for making fine glass filaments.** BORNKESSEL BRENNER UND GLASMASCHINEN G.M.B.H. Ger. 540,096, March 14, 1929. (*C.A.*)

**Apparatus for drawing glass tubes or rods.** ROBERT SALOMON. Ger. 540,161, July 20, 1928. (*C.A.*)

**Apparatus for making glass tubes or rods of noncircular section.** PATENT-TREUHAND-GES. FÜR ELEK. GLÜHLAMPEN M.B.H. Ger. 540,414, Oct. 3, 1930. (*C.A.*)

**Glass-annealing furnace.** PITTSBURGH PLATE GLASS CO. Ger. 540,938, May 12, 1927. (*C.A.*)

**Glass-drawing apparatus.** B. L. GREGG. Ger. 540,939, Nov. 27, 1927. (*C.A.*)

**Method and apparatus for hardening glass plates, etc., by means of air currents.** SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Ger. 541,006, Jan. 28, 1930; see also *Ceram. Abs.*, **11** [2], 104 (1932). (*C.A.*)

**Method for making window glass.** MAX BICHEROUX. Ger. 542,337, Jan. 28, 1928. Manipulative features are described. (*C.A.*)

**Gas-heated muffle furnace for tempering glassware.** SEBASTIAN SCHIEREN. Ger. 542,412, Dec. 17, 1929. (*C.A.*)

**Hard and heat-resistant glass.** KITUZO HUWA AND SAZI SAKAI (Tokyo Denki K. K.). Japan, 91,280, May 1, 1931. The glass consists of $SiO_2$ more than 70, $B_2O_3$ 16 to 20, PbO less than 10, and alkali less than 5% (containing K less than 2%). It is resistant to high temperature and quick change of temperature and is easily worked. (*C.A.*)

**Furnace for annealing glass.** V. I. KHMELEVSKII. Russ. 23,570, Oct. 31, 1931. Constructional features are given. (*C.A.*)

## Structural Clay Products

**Controlling efflorescence in building brick.** ANON. *Brit. Clayworker*, **40** [479], 443 (1932).—In 40% of the cases of efflorescence the brick manufacturer is responsible, while in 60% he has no control. Causes and cures are discussed. R.A.H.

**Effect of dissolution on the durability of Fletton brick.** G. P. MCHUGH AND E. L. KNIGHT. *Chem. & Ind.*, **51** [14], 107–10 (1932).—A combination of the free acid and the alkali affords a possible explanation of the phenomenon of efflorescence. See also *Ceram. Abs.*, **10** [8], 568 (1931). G.R.S.

**Manufacture of perforated brick.** H. ELLERMEIER. *Tonind.-Ztg.*, **56** [18], 255 (1932).—The form of the mouthpiece of the press should give as small a frictional resistance as possible and the raw materials should be well treated. See also *Ceram. Abs.*, **11** [4], 244 (1932). W.M.C.

**Manufacture of common and hard-fired brick by the dry process.** ANON. *Tonind.-Ztg.*, **56** [26–27], 357–59 (1932).—A review is given of dry-process manufacture. Illustrated. W.M.C.

**Producing an unlimited color range for face brick.** A. D. DRAKE. *Brick Clay Rec.*, **80** [4], 198–200 (1932).—D. gives a detailed description of three general methods for the production of a variety of colors and finishes on face brick. E.J.V.

**Comparative cost of steel-masonry and frame houses.** ANON. *Brick Clay Rec.*, **80** [4], 206–208 (1932).—Illustrated. E.J.V.

**Brick design in the home.** MARC N. GOODNOW. *Christian Sci. Mon.*, **24** [55], 6 (1932).—Brick can be used in home interiors for informal effects in decoration. Illustrated. E.J.V.

**Brick for dry wall construction.** WM. J. WILKINS. *Brick Clay Rec.*, **80** [4], 211 (1932).—Illustrated. E.J.V.

**Clay block displacing stone.** ANON. *Brick Clay Rec.*, **80** [4], 205 (1932).—The surface can be a sanded face or in regular rough face-brick texture. Illustrated. E.J.V.

**Factors influencing the distribution of clay plants in Indiana.** GEORGE I. WHITLATCH. *Clay-Worker*, **97** [4], 202–204 (1932). E.J.V.

**Fundamentals and economies in the clay industries. XV.** ELLIS LOVEJOY. *Clay-Worker*, **97** [4], 200–201 (1932).—Arrangement of the forming machinery in relation to the driers is discussed with a brief explanation of the merits of the slight difference in arrangement with the different types of products. Arrangement of the kilns is also briefly touched upon. For Part XIV see *Ceram. Abs.*, **11** [6], 368 (1932). E.J.V.

**New standard specifications for brick in Yugoslavia.** ANON. *Tonind.-Ztg.*, **56** [32], 429 (1932). W.M.C.

BOOKLET

**English Brickwork Details, 1450–1750.** T. SMALL AND C. WOODBRIDGE. Portfolio, 4 pp., 20 sheets. Architectural Press, London, 1932. Price 8s 6d. Reviewed in *Times Lit. Supp.*, **31**, 135 (1932). H.H.S.

PATENTS

**Tile.** O. T. ANDERBERG. U. S. 1,854,324, April 19, 1932.

**Brick wall construction.** E. M. WYATT (American Face Brick Research Corp.). U. S. 1,854,439, April 19, 1932.

**Making tapestried brick.** H. M. FENATI. U. S. 1,854,788, April 19, 1932.

**Brick.** E. F. RAMMER. U. S. 1,855,987, April 26, 1932. A wall construction comprising a plurality of courses each including a plurality of brick and each brick having opposite faces tapered in opposite directions to provide reduced ends for the intermediate portion of the greatest strength.

**Producing rough-faced ornamental brick.** E. C. HERVEY (Hydraulic Press Brick Co.). U. S. 1,856,055, April 26, 1932.

**Lightweight building materials.** J. S. PECK AND E. V. BARRETT. U. S. 1,856,929, May 3, 1932. The method comprises producing a mixture of water and an argillaceous material and a sufficient amount of a water-soluble gas dissolved therein to produce a porous mass on subsequent heating, then heating the mixture to liberate the gas and form a porous mass.

**Manufacturing brick.** A. J. THERRIEN (National Brick Co.). U. S. 1,857,671, May 10, 1932.

**Roof covering.** A. C. FISCHER (Philip Carey Mfg. Co.). U. S. 1,858,224, May 10, 1932.

**Manufacture of brick, etc.** G. MAKEPEACE AND R. HEMMING (Solihull Brick Co.). Brit. 370,331, April 13, 1932.

**Tile, brick, slab, etc., building or paving material.** G. H. DOWNING, H. R. HOLDING, G. TAGG, AND J. F. TAGG. Brit. 370,613, April 20, 1932.

**Hollow-channel brick and means for closing up the open ends of the channels.** AVAN AKT.-GES. ZUR VERWERTUNG VON ZIEGELPATENTEN. Brit. 371,268, April 27, 1932.

**Porous brick.** C. OTTO & Co., G.M.B.H. Fr. 715,594, April 17, 1931. Light porous brick are made by molding a mixture of clay 1 part and pumice stone 2 parts, drying, and heating to a point which does not pass the melting point of the pumice. The pumice may be replaced by kieselguhr, blast-furnace slag, thermosite, or other light material. (*C.A.*)

**Porous brick and plates.** KARL KOPP. Ger. 541,438, Nov. 19, 1929. A mixture of clay, pumice, and C is molded and then heated up to or above the melting point of the pumice under such conditions that the C is burned. Lignite is a suitable form of C. (*C.A.*)

## Refractories

**Refractories for use in sulphate-recovery furnaces of the pulp and paper industries.** J. A. CUNLIFFE AND H. E. CLEM. *Jour. Amer. Ceram. Soc.*, **15** [6], 321–33 (1932).

**Uses of heat insulation.** B. TOWNSHEND AND E. R. WILLIAMS. *Chem. Met. Eng.*, **39** [4], 219–22 (1932).—The development of insulation is traced from the early 70's. Tables of physical and thermal properties of some heat-insulating materials and curves of thermal conductivity at different temperatures are presented Requirements are discussed. G.R.S.

**Manufacture of highly refractory products in America.** P. P. BUDNIKOFF. *Amer. Tech. Prom.*, No. 8, pp. 498–601 (1931); *Feuerfest*, **8** [2], 25–26 (1932).—B. describes in detail the manufacture of alumina, magnesite, and chromite brick, mullite and silicon carbide objects, and the production of Carbofrax. See also *Ceram. Abs.*, **11** [4], 236 (1932). M.V.K.

**High-duty heat insulations.** ANON. *Rev. Tech. Luxembourgeoise*, **23**, 83–84 (March-April, 1931).—The properties of "Sterchamol" heat-insulating material are described. (*J.I.S.I.*)

**General properties of refractories.** J. A. RUBIO. *Rev. Ing. Ind.*, **19**, 391–95 (1931). (*C.A.*)

**Refractories.** C. MEURICE. *Ing. chim.*, pp. 97–112 (1931); abstracted in *Refrac. Jour.*, **8** [4], 160 (1932).—Modern methods applied in the physical and chemical testing of refractories and refractory compositions are described. See also *Ceram. Abs.*, **11** [1], 34 (1932). E.P.R.

**Proportioning refractory materials.** S. KONDO. Abstracted in *Refrac. Jour.*, **8** [4], 160 (1932); for abstract see *Ceram. Abs.*, **10** [5], 351 (1931). E.P.R.

**Refractory compositions.** G. ZIERER. Abstracted in *Refrac. Jour.*, **8** [4], 160 (1932); for abstract see *Ceram. Abs.*, **11** [4], 251 (1932). E.P.R.

**Alumino-silicate refractories.** G. A. BOLE. *Metals & Alloys*, **3**, 15–21 (1932). (*B.C.A.*)

**Silica brick.** LONGCHAMBON. Abstracted in *Refrac. Jour.*, **8** [4], 160 (1932); see also *Ceram. Abs.*, **10** [12], 845 (1931). E.P.R.

**New method of representing the composition of refractory clay.** SHOICHIRO NAGAI AND AKITARO MANNAMI. *Jour. Jap. Ceram. Assn.*, **38** [450], 328–36 (1930). S.K.

**Drying of bauxite.** JÓZSEF FINKEY. *Bányász. Kohász. Lapok*, **64**, 445–50, 466–73 (1931).—Experiments on bauxite containing about 17% water showed that the quantity of heat required for the drying is made up of the heat required (1) to heat the ore to 100°, (2) to remove hygroscopic water at 100°, (3) to heat the ore containing water of hydration from 100 to 530°, and (4) to dehydrate the ore. This last heat comprises (*a*) the heat of dehydration and (*b*) the heat of evaporation. The specific heat of the bauxite on the basis of its percentage composition was estimated to be about 0.2. The results of an experiment were heat for (1) + (3) 68,136 cal., (2) 124,620, and (4) (*a*) + (*b*) 196,107 cal., totaling 388,863 cal. The drying of a metric ton of bauxite would thus require 582,130 cal., or about 116 kg. of a 5000-cal. coal. The ores dried at 530° took up 5 to 6% moisture during standing for 4 weeks. Repeated drying at 105° reduced this water content to 1.5%. Thus the drying of bauxite does not yet seem economical. (*C.A.*)

**Aluminum sulphate; its production from clays from the district of Polevski.** V. PERSHKE AND N. LASHIN. *Jour. Chem. Ind.* [Moscow], **7**, 954 (1930); *Ind. chimique*, **18** [214], 795 (1931).—White clays with an average 34.1% alumina content are treated with sulphuric acid to produce raw aluminum sulphate. The disintegration of uncalcined clay by sulphuric acid of 40 Bé is slow and produces only small quantities of aluminum sulphate. On the other hand, with clay calcined at 700° for 2 hr., and then treated with sulphuric acid for 7 hr., the surplus acid being neutralized by a 15% addition of clay, the yield is 87.6% of aluminum sulphate 5 hr. after the beginning of the reaction. The insoluble residue contains 78.6% silica which is used for preparing sodium silicate by boiling it for 1 hr. with caustic soda. The silicate contains about 43% $SiO_3Na_2O$ or $SiO_3K_2$ and an insignificant quantity of free caustic soda. M.V.K.

**Reversible thermal expansion of refractories.** W. J. REES. *Brit. Clayworker*, **40** [480], 7 (1932).—There is no real difference between "thermal expansion" and "reversible thermal expansion" except in rare cases when the expansion which takes place on heating is of a permanent character and is consequently described as an "after-expansion" and not as "thermal expansion." An increase in the porosity of a fire brick causes a decrease in the reversible thermal expansion up to a porosity of 50%, but does not produce irregularities in the expansion curve. R.A.H.

**Permeability of refractories.** BATTA AND SHEEPPERS. *Ind. chimique*, **18** [213], 700 (1931).—Study of permeability before use gives indications of the homogeneity of the product. The corrosion of refractories and their chemical resistance to gases are in close relationship with their porosity and permeability. M.V.K.

**Protection of refractory materials with colloidal graphite.** ANON. *Ind. chimique*, **18** [214], 838 (1931).—Researches made in the laboratory of Verein zur Uberwachung der Kraftwirtschaft des Ruhrzechen, Germany, did not confirm the hypothesis that a coat of colloidal graphite (Hydrokollag) can protect refractory materials against the action of kiln gases. The tests were made in a blast furnace with reduced atmosphere

in the presence of corrosive cinders. Both diluted and undiluted Hydrokollag were used. In both cases graphite burned up almost completely and consequently refractories treated with Hydrokollag did not behave better than others. M.V.K.

**Magnesia refractories.** ANON. *Ind. chimique*, **19** [216], 65 (1932).—Methods and conditions of manufacture are given. M.V.K.

**Significance of refractory materials.** A. T. GREEN. *Fuel Econ.*, **6**, 529–45 (1931).—The expansion, structural stability, texture, spalling, thermal characteristics, *e.g.*, heat capacity and conductivity, corrosion, and resistance to erosion of refractories are briefly discussed. (*J.I.M.*)

**Refractory tests. Laboratory vs. mill conditions.** W. C. KERNAHAN. *Heat Treating & Forging*, **17**, 576–78 (June, 1931); for abstract see *Ceram. Abs.*, **10** [8], 575 (1931). (*J.I.S.I.*)

**Gas permeability as testing method for grog bodies.** Y. KVASHENINIKOV AND K. KUMANIN. *Ceramics & Glass*, **8** [1], 24–26 (1932).—Changes of gas permeability, water absorption, and shrinkage in dependence on the grain size of the grog, proportion of clay and grog, and temperature of firing of the grog body were investigated on nine grog masses. The apparatus is described. It was found that (1) the gas permeability of a grog body is much more affected by the factors of working than water absorption and shrinkage. (2) The firing temperature has the greatest influence on the gas permeability of the body followed by the size of grains and the proportion of clay to grog. (3) With increased firing temperature, the gas permeability increases. (4) An increased clay content in the mass decreases the gas permeability and water absorption of the body and increases its shrinkage. M.V.K.

**Preparing firebrick material.** ANON. *Brit. Clayworker*, **40** [480], 9–10 (1932).—Methods are discussed for preparing unweathered clay for firebrick manufacture. R.A.H.

**Structural materials for modern heat technology.** F. H. NORTON. *Chem. Met. Eng.*, **39** [4], 226–28 (1932).—Refractories are classified into the following groups: those used (1) to confine heat within a definite space, (2) to contain a charge such as blocks in the bottom and sides of a glass tank or walls of a coke oven, (3) to protect structural members from influence of high temperature, (4) to conduct heat through a tight wall, such as muffles, recuperators, and retorts, and (5) to absorb heat such as regenerator checkers. The properties of refractories in each class are given in tabular form. Requirements of refractories are discussed under the headings of fusion point, thermal conductivity, coefficient of expansion, and ability to resist temperature changes. The composition and properties of the different types of refractories are shown in a table. Two groups of curves give changes in expansion and thermal conductivities of refractories with changes in temperature. A discussion is given of a number of considerations to be used in selecting the best refractory for a given purpose and also of three types of refractory cements. G.R.S.

**Refractory materials: fireclay brick.** COLIN PRESSWOOD. *Metallurgia*, **5** [29], 169–72 (1932); for abstract see *Ceram. Abs.*, **10** [10], 706 (1931). M.V.K.

**"Laclede mullite" announced.** ANON. *Amer. Glass Rev.*, **51** [29], 17 (1932). E.P.R.

**Dilatation and sensitivity to heat of refractory brick in the cement industry.** K. ENDELL. *Rev. mat. constr. trav. pub.*, No. 270, pp. 111–15 (1932).—Besides the continuous variation in length of refractories with the temperature, there exists another kind of dilatation which depends on a reversible change in the physical state of some crystalline constituents, a change connected with a variation in volume. The latter kind of dilatation is especially important in the $SiO_2$ system. Tables show changes in specific gravity, specific volume, increase in volume and length of $\alpha$-quartz, $\alpha$-cristobalite, $\alpha$-tridymite, $\beta$-cristobalite, and quartz glass; also a linear dilatation conditioned by the transformation of different forms of $SiO_2$ into each other at high temperatures. Besides this variable dilatation and permanent dilatation, a permanent contraction exists which is conditioned by the shrinkage of clay particles fired at insufficiently high temperatures. The importance of these tensions depends on (1) the size and volume of the brick, (2) coefficient of dilatation, and (3) variations of temperature. When tensions exceed the limit of resistance, they produce a disaggregation or even a destruction of the structure of the brick. The property of the brick to react against a change of shape or volume due to pressure, tensile strength, or torsion, produced by irregular heating or cooling, is elasticity. When the limit of elasticity is exceeded, a permanent variation in length appears (plastic deformation). The limit of elasticity is highly important in the case of a growing sensitivity of refractory brick to heat. If, during the increasing of temperature, the limit of elasticity is exceeded and a permanent variation in state occurs,

then the tensions within the brick equalize and the brick is no longer as sensitive to temperature. All refractories are more stable at temperatures higher than 650°; this fact was substantiated in practice where it was observed that all refractories are unaffected by temperatures above dark red. Tests to ascertain the resistance of refractory products to temperature variations are described. M.V.K.

**Determination of the quality of Dinas brick.** A. S. GINSBERG, B. P. SELIVANOV, AND A. I. TZVETKOV. *Metallurg* [Russia], **5** [3], 344–59 (1930).—The existing standards of determining the quality of Dinas brick were critically examined. According to Groum-Grjimailo, the quality is determined by the degree of transformation of the quartz into tridymite (with a resulting change in density) and the chemical composition. The U.S.S.R. standards comprise three grades and demand a fusion point of 1710° for grades I*a* and I*b*, and 1670° for grade II. The compression strengths of grades I and II are 125 and 90 kg./sq. cm., respectively, and the densities not greater than 2.38 and 2.42. Chemically, grade I*a* is $SiO_2 > 94\%$, $CaO + Fe_2O_3 < 7\%$, grade I*b* is $SiO_2 > 92\%$, $CaO + Fe_2O_3 < 2\%$, and grade II is $SiO_2 > 90\%$, no other specified components. It is pointed out that the usual method of density determination is inaccurate since it is dependent on the fineness to which the material is ground. A number of corrections are described which increase its reliability. A much more reliable method is micrographical analysis, as it reveals changes of structure which profoundly affect the quality of the brick without materially altering the density, *e.g.*, a transformation of the quartz into cristobalite instead of into tridymite or into a glass which will eventually give the desired tridymite. (*J.I.M.*)

**Dinas brick under the microscope.** W. N. SCHVETZOV. *Uralskiy Teknik*, **4** [7], 15–23 (1928).—The Leitz polarizing microscope is described and its value in the examination of materials used in the manufacture of Dinas brick is illustrated. (*J.I.M.*)

**Manufacture of black Dinas brick at the Tchusov Works.** W. W. KALIKIN. *Uralskiy Teknik*, **3** [11–12], 40–44 (1927).—The introduction of silicides of low melting point into Dinas brick assists recrystallization and prevents spalling. (*J.I.M.*)

**Black Dinas brick.** W. N. SCHVETZOV. *Uralskiy Teknik* [Russia], **3** [5], 36–38 (1927).—Slagging tests on Dinas brick indicate that the clay content must be less than 0.5% and the lime content more than 2.5%, the best results being obtained with 3% of lime. The quartz of quartzite should not be coarser than 3 mm., and an angular grain is preferable to a rounded one. By introducing iron oxide or old Dinas as fine dust into Dinas brick, the composition and structure can be made to resemble those of brick which have already been in service. (*J.I.M.*)

**Impervious tubes of pure alumina.** FRANK ADCOCK AND DONALD TURNER. *Jour. Sci. Instruments*, **7**, 327 (1930).—Small tubes of pure alumina about $^1/_{10}$-in. diameter and $^1/_{20}$-in. bore have been glazed externally in an oxyhydrogen flame. Such tubes are practically impervious to gases at room temperature and are suitable for refractories above the temperature (about 1600°C) for which "Pythagoras material" can be used. (*J.I.M.*)

**Shaping refractory products out of half-dried mixtures.** P. P. BUDNIKOFF, S. A. GICHAREVITSCH, AND I. G. SCHACHNOVITSCH. *Feuerungstechnik*, **20** [3], 46 (1932); for abstract see *Ceram. Abs.*, **10** [6], 433 (1931). M.V.K.

**Refractories in metallurgy.** C. E. WILLIAMS. *Metals & Alloys*, **3**, 3–11 (1932); abstracted in *Refrac. Jour.*, **8** [4], 160 (1932).—An extensive study has been made of the applications of refractories and refractory products in metallurgical operations. The results are recorded and critically discussed. E.P.R.

**Unfired magnesite brick for the metallurgical industry.** A. E. FITZGERALD. *Metals & Alloys*, **3**, 25 (1932); for abstract see *Ceram. Abs.*, **11** [4], 248 (1932). (*B.C.A.*)

**Silicon carbide and its application in metallurgy.** H. R. HOUCHINS AND C. MCMULLEN. *Metals & Alloys*, **3**, 12–14 (1932).—Some commercial uses are recorded in which SiC is employed as a refractory and as an electric resistor. (*C.A.*)

**High-grade refractories for the metal industry.** W. STEGER. *Metallwirtschaft*, **9**, 528–32 (1930).—A summary is given of the most important properties of commercial alumina, chromite, silicon carbide, and zircon brick. (*J.I.M.*)

**Foundry refractories.** J. R. ALLAN. *Trans. & Bull. Amer. Foundrymen's Assn.*, **2** [12], 569–84 (1931); for abstract see *Ceram. Abs.*, **11** [3], 181 (1932). (*C.A.*)

**Bonding magnesite linings for steel-melting furnaces without use of iron oxide.** L. JORDAN. *Metals & Alloys*, **3**, 22–24 (1932).—MgO ground in $H_2O$ appeared to give as strong a refractory in the rammed layer as did Zr silicate. An indirect arc rocking furnace was lined with a mixture of 240 lb. of dry-ground electrically sintered MgO (50% passing 80-mesh) and 100 lb. of electrically sintered MgO slip containing rather more than 50% MgO. The brickwork was painted over with a similar slip, and the

mixture rammed to a thickness of 1.5 to 3 in. An even more satisfactory mixture for patching contained 2 parts of sintered MgO (< 30-mesh) and 1 part each of alundum and kaolin. (*B.C.A.*)

**Refractories for blast furnaces and hot blast stoves.** W. G. GIRLING. *Iron & Steel Ind. & Brit. Foundryman*, **5**, 95–96 (1931). (*C.A.*)

**Refractories service conditions in boiler furnaces.** ANON. *Refrac. Jour.*, **8** [4], 150 (1932); for abstract see article by R. A. Sherman, *Ceram. Abs.*, **10** [6], 438 (1931). E.P.R.

**Selection of fire brick for boiler furnaces.** ALFRED B. SEARLE. *Steam Eng.*, **1**, 69–70 (1931). (*C.A.*)

**Unfired magnesite refractories in rotary cement kilns.** A. E. FITZGERALD. *Pit & Quarry*, **24** [2], 38 (1932).—Highly aluminous brick are superior to clay brick because they suffer less from vitrification and form more refractory mixtures with cement clinker than do clay brick. Mixtures of cement clinker and unfired magnesite brick are even more refractory than clinker-high alumina brick mixtures, and so allow the operator to fire at much higher temperatures than heretofore. E.P.R.

**Melting point of minerals in an electric short-circuit kiln.** O. WEIGEL AND F. KAYSSER. *Neues Jahrb. Min. Geol., Beil.-Bd.*, **64***A*, 321–96 (1931); *Sprechsaal*, **65** [14], 257 (1932).—The authors discuss the chief types of kilns for obtaining very high temperatures and describe in detail the electric short-circuit kiln of W. Nernst and G. Tammann. The melting of aluminum oxide (corundum) was found to be almost independent of the atmosphere present in the kiln. The probable value lies at 2010 ± 10°C. The melting point of magnesia spinel was found to depend on the kiln atmosphere. With oxidizing firing, changes in spinel appeared at over 2050°, although it is difficult to determine the melting point exactly by means of the optical method. Reduced firing seems to remove MgO from the spinel (reduction process). Chrysoberyl melts sharply at 1817 ± 6°. Phenakite disintegrates, in small measure, at a little over 1600°. Bentonite melts at 1370 to 1380°, apparently independently of the kiln atmosphere; beryl shows a melting inertness and begins to melt at about 1490°. Some zinc and iron spinels were also investigated. M.V.K.

**Changes in grog during operation in a glassmelting kiln.** D. S. BELIANKIN. *Ceramics & Glass*, **8** [1], 12–14 (1932).—From the chemico-mineralogical point of view, grog is a good refractory for glassmelting kilns. It is resistant to the action of glass and batch dust although this resistance is considerably lowered in the case of a highly basic glass. M.V.K.

**Japanese tank blocks.** MINEICHI MASUDA. *Jour. Jap. Ceram. Assn.*, **38** [449], 253–62 (1930).—The results of physical and microscopical tests are given on three blocks which were used under the flux line of a side wall of the same tank furnace for about a year at the Tokunaga Glass Works in Osaka. S.K.

**Glassmelting pot. IV. Resistance to corrosion.** SEIJI KONDO AND MASANOBU NAKATSUJI. *Jour. Jap. Ceram. Assn.*, **40** [471], 143–47 (1932).—The resistance of various bodies composed of a grog, a ball clay, and a plastic kaolin to corrosion of 0.3 $PbO{\cdot}SiO_2$, $Na_2O{\cdot}SiO_2$, and $B_2O_3{\cdot}SiO_2$ glasses has been measured directly and indirectly. In the direct method, small cylindrical test pieces fired to cone 14 were heated in the raw glass mixtures, and their diameters were measured before and after the heating. In the indirect method, the P.C.E. of the bodies mixed with an equal volume of the lead silicate or borosilicate batch was determined. The results indicate that (1) among various factors influencing the resistance the porosity of the bodies is most important; (2) the relation between the grog content and the corrosion varies with the raw materials; and (3) the corrosion does not agree well with the P.C.E. S.K.

**Bauxite in France. V.** V. CHARRIN. *Ind. chimique*, **18** [214], 774–77 (1931).—C. discusses the French laws regulating the production of bauxite and gives a list of companies and the methods used for the extraction of bauxite. For Parts II, III, and IV see *Ceram. Abs.*, **11** [6], 371 (1932). M.V.K.

**Chief properties of refractory clays of the Latninsky deposits.** V. P. ZUBCHANINOV. *Ceramics & Glass*, **8** [1], 27 (1932).—Z. discusses the results of detailed investigations made by the State Ceramic Institute on refractory clays of the Latninsky deposits. M.V.K.

**Certain rocks bearing cyanite and sillimanite in the Bhandara District, C. P.** S. K. CHATTERJEE. *Rec. Geol. Surv. India*, **65**, 285–305 (1931).—The cyanite- and sillimanite-bearing rocks are always associated with chlorite-muscovite schist and intersected by myriads of quartz veins carrying tourmaline, rutile, and occasionally roscoelitic mica. There are a variety of rocks bearing the cyanite and sillimanite. Besides these two minerals, which are mutually exclusive of each other, tourmaline, rutile, quartz and

muscovite are essential ingredients. It is suggested that the chlorite-muscovite schists yielded the rocks bearing cyanite and sillimanite as the result of pneumatolytic and hydrothermal metamorphism attendant upon the intrusion of tourmaline-muscovite granite and involving the operation of $B_2O_3$ or borates, and occasionally vanadates, derived from its residual magma liquor. (*C.A.*)

**Bauxite deposits at Gánt in western Hungary.** E. DITTLER. *Berg.- und hüttenm. Jahrb. Leoben*, **78**, 45 (1930); *Neues Jahrb. Mineral. Geol.*, Referate II, p. 29 (1931).—Six analyses of bauxites are given. The relation between chemical composition and depth is shown. (*C.A.*)

**Advance in the refractory field in U. S. in 1931. II.** W. STEGER. *Feuerfest*, **8** [3], 37–42 (1932); for Part I see *Ceram. Abs.*, **11** [6], 371 (1932). M.V.K.

**World production and resources of chromite.** L. A. SMITH. Amer. Inst. Mining Met. Eng., *Tech. Pub.*, No. 423 (1931).—Statistical information is given showing the world's production of chromite during the period 1890 to 1929, together with the imports, exports, and consumption by the different countries for 1928. The world's resources of chromite are also reviewed. (*J.I.S.I.*)

**Kuznetskstroy metallurgical plant.** ELLSWORTH PRICE OGDEN. *Clay-Worker*, **97** [4], 205 (1932). E.J.V.

BULLETINS

**Refractoriness under load.** JOHN G. STEIN & CO. *Refractories Bull.*, No. 3; abstracted in *Refrac. Jour.*, **8** [4], 156 (1932).—The bulletin is illustrated by Mellor-Moore curves for fireclay and silica brick. E.P.R.

**Refractories in furnace construction.** SCHACK. *German Ironmasters' Assn. Bull.*, No. 155 (1932); abstracted in *Refrac. Jour.*, **8** [4], 160 (1932).—S. discusses the relation between laboratory and practical service tests, together with the technique of heat problems in relation to furnace construction. E.P.R.

PATENTS

**Making refractory insulating material.** V. M. GOLDSCHMIDT. U. S. 1,854,899, April 10, 1932. A process for the production of a highly refractory insulating material comprising mixing a natural product rich in magnesium orthosilicate with a substance rich in magnesium taken from a group consisting of magnesium oxide or magnesite and with a substance taken from a group consisting of sawdust, peat powder, cork waste, coal, anthracite, maize grains, rice husks, and similar organic and inorganic bodies.

**Method and material in the manufacture of refractory articles.** H. E. WHITE (Lava Crucible Co.). U. S. 1,856,303, May 3, 1932. A refractory article containing mullite having finely divided metal incorporated therein, the metal having reaction characteristics substantially similar to those of the aluminum-magnesium group.

**Producing refractory, acid-proof, and other ceramically bonded products.** HUGO ACKERMANN. U. S. 1,856,613, May 3, 1932. A process of making refractory, acid-proof, and other ceramically bonded products, comprising mixing aluminous binding material of less plasticity than clay with water to render the mixture to castable consistency with an electrolyte, adding to the mixture ground nonplastic material to form a noncastable mass capable of being shaped, shaping under pressure, drying, and firing the mass.

**Sintering refractories from molten magnesite, etc.** HEINRICH NEUHAUSS (Ajax Metal Co.). U. S. 1,856,851, May 3, 1932. The method of forming and sintering a refractory for holding molten metals which consists in forming and sintering first the surface of the refractory which is to receive the molten metal and subsequently and successively forming and sintering the backing of the refractory.

**Lining for furnaces.** R. P. SOUTH (Lava Crucible Co.). U. S. 1,857,103, May 3, 1932.

**Furnace wall structure.** EDWIN LUNDGREN (International Combustion Engineering Corp.). U. S. 1,857,561, May 10, 1932.

**Production of aluminum oxide, etc.** T. R. HAGLUND. U. S. 1,857,844, May 10 1932. Process for refining raw material containing aluminum oxide consisting in forming a slag containing aluminum sulphide, decomposing aluminum sulphide by treating the slag with water, and removing impurities of sulphides by treating the decomposed slag while in suspension in water with chlorine.

**Obtaining aluminum hydrate.** T. O. MCADOO (International Silica Corp.). U. S. 1,858,165, May 10, 1932. A process of producing alumina from shales containing chemically combined alumina, silica, and iron, which consists in digesting the shales

in a mixture of hydrochloric and hydrofluoric acids and water, heating under pressure the solution thus formed, precipitating the silica content from the solution by the addition of a substantially small amount of alkali thereto, precipitating the iron content from the solution by the addition of a further amount of alkali sufficient to form aluminate, and, finally, precipitating the alumina from the aluminate solution by the addition of an acid to the solution.

**Recovery of alumina from aluminous siliceous material.** ELECTRIC SMELTING & ALUMINUM CO. Brit. 369,593, April 6, 1932.

**Refractory brick.** R. P. HEUER. Brit. 370,013, April 13, 1932.

**Fire brick, etc.** R. LOSSNITZ. Brit. 370,435, April 20, 1932.

**Ceramic masses particularly applicable to the manufacture of fire-resistant articles.** R. LOSSNITZ. Brit. 370,501, April 20, 1932.

**Preparation of alumina.** LONZA-WERKE ELEKTROCHEMISCHE FABRIKEN GES. Brit. 371,112, April 27, 1932.

**Alumina and compounds thereof.** ALTERRA AKT.-GES. Brit. 371,235, April 27, 1932.

**Alumina.** LONZA-WERKE ELEKTROCHEMISCHE FABRIKEN GES. Brit. 371,259, April 27, 1932.

**Refractory blocks.** SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Brit. 371,272, April 27, 1932.

**Separating aluminium hydroxide from silicic acid.** ALTERRA AKT.-GES. Brit. 371,307, April 27, 1932.

**Manufacture of tridymite stones.** H. SALMANG. Brit. 366,114, Dec. 25, 1930. Ground $SiO_2$, of which at least 50% is a fine powder, is mixed with sulphite lye, 2% of $CaCO_3$, 1.5% of $Na_2CO_3$, and 1.5% of $Fe_2O_3$, and the mixture is fired for 20 hr. at about 1250°, whereby almost complete conversion of quartz into tridymite is obtained. (*B.C.A.*)

**Refractory products.** MORGAN CRUCIBLE CO., LTD. Fr. 710,911, Feb. 6, 1931. Refractory articles are made by heating a mixture of Si and graphite to produce a SiC bond *in situ*, the proportions being such that the finished article contains free C in the form of graphite. Other refractory substances may be added to the composition. Thus, plumbago 25, Si 20, and SiC 55 precipitates are shaped with a temporary binder such as tar and fired at about 1400°. Other examples are given. (*C.A.*)

**Aluminates.** SOC. D'ÉLECTROCHIMIE, D'ÉLECTROMÉTALLURGIE ET DES ACIÉRIES-ÉLECTRIQUES D'UGINE. Fr. 714,275, July 7, 1930. Lyes of aluminates obtained by treating bauxite with soda are filtered through a bed of bauxite, calcined or not. When the bauxite becomes saturated with $Al_2O_3$ it is returned to the cycle of operations for recovery of the whole of this $Al_2O_3$. (*C.A.*)

**Zirconium compounds.** BOZEL-MALÉTRA (Soc. industrielle de produits chimiques). Fr. 714,283, July 8, 1930. Zr carbides are obtained by reducing Zr ores with C in an electric furnace. If insufficient C is used a mixture of carbides and fused $ZrO_2$ is obtained which may be used directly as an abrasive. Fr. 714,284 describes the preparation of $ZrO_2$ by using silicate ores of Zr with NaOH and hydrolyzing the product, preferably under pressure, with water. The hydrolysis may be repeated as often as necessary. Fr. 714,285 describes the purification of $ZrO_2$ from oxides of Fe by heating it to at least 400° so as to render the $ZrO_2$ insoluble in HCl and the oxides of Fe are then removed by HCl. (*C.A.*)

**Alumina.** LONZA-WERKE ELEKTROCHEMISCHE FABRIKEN G.M.B.H. Fr. 715,271, March 5, 1931. Pure $Al_2O_3$, particularly suitable for obtaining Al and Al salts, is prepared by dissolving an alkaline earth aluminate in aqueous salt solutions, *e.g.*, solutions of alkaline earth salts, and precipitating $Al_2O_3$ from the solutions. (*C.A.*)

**Synthetic spinels.** I. G. FARBENINDUSTRIE AKT.-GES. Fr. 716,281, April 29, 1931. In making synthetic spinels of a yellow color, the support of the color used is composed of Mn and Fe, *e.g.*, to a mixture of Al 90 and Mg 10% are added $MnO_2$ 4 and Fe 1%. See also *Ceram. Abs.*, **11** [6], 373 (1932). (*C.A.*)

**Refractory pieces.** CORNING GLASS WORKS. Fr. 716,730, May 7, 1931. Aluminous refractory pieces are bound by adding $H_3PO_4$ to the mass under such conditions that the acid will react *in situ* to form a fine colloidal film of Al phosphate around each grain. (*C.A.*)

**Alumina.** VEREINIGTE ALUMINIUM-WERKE A.-G. Fr. 716,748, May 7, 1931. Pure $Al_2O_3$ is obtained from crude materials fused with metal sulphides and a reducing agent, the fusion bed of $Al_2O_3$·$Al_2S_3$ obtained being refined by repeated fusion with refining agents, as well as by recrystallization and cooling between the two fusion processes, with consecutive reheating. (*C.A.*)

**Alumina.** ALUMINIUM, LTD. Ger. 537,894, Nov. 19, 1926; see Brit. 262,405, *Ceram. Abs.*, **7** [7], 459 (1928). (*C.A.*)

**Disintegrating natural alumite.** SOCIETÀ ITALIANA PER LE INDUSTRIE MINERARIE E CHIMICHE. Ger. 540,533, Aug. 7, 1930. Alumite is calcined and leached out with alkali carbonate solution such as crude potash solution. The calcined alumite may be suspended in water before addition of the leaching-out solution. An example is given describing the preparation of $Al(OH)_3$ from natural alumite by this method. (*C.A.*)

**Working up aluminous materials.** MAX BUCHNER. Ger. 541,361, Dec. 25, 1926. Aluminous materials are dissolved or purified by treatment with $HNO_3$ at a raised temperature and pressure in vessels made of known alloys containing Fe, Cr, and Ni, with or without other metals, *e.g.*, W. An excess of aluminous material may be used and the temperature and pressure may be raised gradually during the process, *e.g.*, to 140° and 6 to 8 atmospheres. See also *Ceram. Abs.*, **10** [5], 359 (1931). (*C.A.*)

**Preparing highly refractory masses and brick.** BERTHOLD REDLICH. Ger. 541,380, Jan. 6, 1932; *Feuerfest*, **8** [3], 43 (1932).—At least 60% alumina which has been fused and cooled is thoroughly mixed with additions of fluxes such as iron oxide or silica and magnesite fired to vitrification. The mixture is pressed or stamped and subjected to a firing temperature of 1400 to 1500°C. This method permits the production of brick of the spinel type at a temperature of the finishing firing of only 1400 or 1500°. It can be made in an ordinary gas kiln. M.V.K.

**Alumina and activated carbon.** HARUKITI MITARASI. Japan. 91,438, May 16, 1931. Dried grains prepared from a mixture of bauxite (or silicates of Al, clay, and other substances containing $Al_2O_3$), anthracene or coal-tar distillate, and sawdust are heated in a closed vessel at 500 to 1000° for 1 to 3 hr. The product is treated with mineral acids or caustic alkalis while hot. From the solution $Al_2O_3$ is obtained, and from the residue, activated C. (*C.A.*)

**Treating clays, bauxites, or other minerals containing alumina.** A. A. KHAKIN AND V. L. LUKASHEV. Russ. 23,387, Oct. 31, 1931. Al-containing minerals are first treated with $AlCl_3$ or HCl in an amount insufficient for the formation of $AlCl_3$, followed by heating in an autoclave under pressure together with $CaCl_2$ or another alkaline earth metal chloride in the presence of $CO_2$ gas, thus producing $AlCl_3$ and alkaline earth carbonate. (*C.A.*)

## Terra Cotta

**Softening behavior of porcelain body.** SEIJI KONDO AND HIROSHI YOSHIDA. *Jour. Jap. Ceram. Assn.*, **38** [452], 467–82 (1930).—(*A*) *Test pieces.* Small cylindrical pieces were molded with 66 porcelain bodies and were fired to cones 13 to 14. (*B*) *Softening behavior.* Each specimen was heated in an electric furnace under a load of 0.5 kg. per sq. cm. with a constant rate, and its change in heat was plotted against temperature. *Conclusions:* (1) The relation between the compositions of the bodies and the softening temperatures is not simple. Those poor in clay, rich in Amakusa liparite, or rich in feldspar showed generally low softening temperatures. (2) The relation between the temperatures at which the cylinders were compressed as much as 5% of their heat and their composition is more simple, those rich in clay being generally stronger than those rich in the liparite or feldspar. (3) P.C.E. is only a rough measure of the softening point. (4) An abnormal expansion at about 1400° was observed in many bodies rich in feldspar. (5) Fine grinding of a body raised the softening temperature quickly and the temperature of 5% yielding slightly further grinding seemed to lower these temperatures. The coarse bodies showed an abnormal expansion at 1300 to 1400°. S.K.

**Use of decomposed liparite.** JIROKICHI KUMAZAWA. *Jour. Jap. Ceram. Assn.*, **38** [452], 483–87 (1930).—The development of the porcelain industry in Japan is closely related with the discovery of suitable decomposed liparite. Analyses of 20 liparites in use are given. K. has succeeded in producing satisfactory earthenware of the rocks. The ware is fired to cones 05a to 8. For temperatures over cone 1a, raw leadless glazes have been developed. S.K.

**Miscellaneous problems in pottery.** JIROKICHI KUMAZAWA. *Jour. Jap. Ceram. Assn.*, **38** [450], 353–56; [451], 422–26; [452], 506–11; [453], 589–92; [454], 666–69; [456], 812–14 (1930).—Discussions are given on wood ashes, zaffre, coal firing, porcelain glaze for coal firing, method of firing porcelain with coal, porcelain ware fit

for coal firing, low-fire raw glaze, classes of porcelain glaze, satisfactory earthenware glazes, low-fire glazes, colored glazes for porcelain or earthenware, pebbles for drum mills, and Japanese zircon. The results of the experiments are given. S.K.

**Special products in brick.** E. WINKLER. *Tonind.-Ztg.*, **56** [29], 384–85; [31], 410–12 (1932).—W. reviews different types of roofing and hollow tile. Some mouthpieces for extruding machines are described which are used in the manufacture of the tile. W.M.C.

**Engobing ceramic products.** B. SPITTA. *Tonind.-Ztg.*, **56** [28], 372–73 (1932).—In this paper a general outline is given of the coating of ceramic products with an engobe. W.M.C.

**Manufacture of black tile.** RICHARD FRANZMEIER. *Deut. Ziegel-Ztg.*, No. 18, p. 241 (1931); *Rev. mat. constr. trav. pub.*, No. 270, pp. 47–48*B* (1932).—The coloring of a smoked tile is produced by the transformation of iron oxide into ferrous oxide under the reducing action of carbon monoxide produced by an incomplete combustion in the kiln and minute particles of graphitic carbon deposit in the pores of the ware. This decomposition begins at about 400° and is very intense and complete at 800 to 900°. M.V.K.

**Modern tile.** C. A. H. *Christian Sci. Mon.*, **24** [96], 9 (1932).—The types, colors, and finishes of modern ceramic tile for use in the home are discussed. E.J.V.

**New homes in old houses.** JOHN H. ROSENTHAL. *Kunst*, pp. 33–39 (Nov., 1931). (*D.I.*)

**The skyscraper's challenge to sculpture.** E. A. JEWELL. *Current History*, **35**, 655–60 (1932).—The "new school of architecture" (skyscrapers) calls for a new school of sculpture. H.H.S.

**Beauty in industrial architecture.** A. TRYSTAN EDWARDS. *World Today*, pp. 477–86 (Nov., 1931). (*D.I.*)

**A home in Vienna.** WOLFGANG BORN. *Innen Dekoration*, pp. 362–73 (Oct., 1931). (*D.I.*)

**Medieval architecture produced with clay products.** ANON. *Brick Clay Rec.*, **80** [4], 201 (1932).—The use of terra cotta to reproduce medieval architecture in a Brooklyn church is described. Illustrated. E.J.V.

BOOKS

**The History of the Maya.** T. GANN AND J. E. THOMPSON. x + 264 pp. Scribners, 1932. Price $2.00. Reviewed in *Times Lit. Supp.*, **31**, 113 (1932). H.H.S.

**Turan: Islamic Architecture in Central Asia.** ERNST COHN-WIENER. Verlag Ernst Wasmuth, Berlin, 1931. Reviewed in *London Studio* [Atelier], **103**, 58 (1932). H.H.S.

PATENTS

**Flowerpot.** T. P. WELLS (T. K. Hudson). U. S. 1,856,179, May 3, 1932.

**Salt-glazing stoneware.** HANS BONTE. Ger. 540,254, June 16, 1929. Parts required to be kept unglazed are coated with a thin layer of material rich in $Al_2O_3$ or MgO, *e.g.*, residues from the manufacture of Al or powdered waste from the manufacture of abrasives such as corundum. (*C.A.*)

## White Wares

**Calcined alumina in the pottery industry.** BERNARD MOORE. *Chem. Trade Jour.*, **90** [2441], 331 (1932).—M. gives details of the researches made to eradicate silicosis from the pottery industry. The principal discovery was that some material other than powdered flint might be used for what is known as china placing. It was found that flint mixed under favorable conditions with the bone ash, which constitutes about 50% of the English china body, caused some of the latter to decompose. Promising results were obtained by the substitution of 75% of calcined bone and 25% calcined alumina for flint. It was found that bone china placed in this material withstood extra firing without decomposing, and, in addition, that there was a marked improvement in the color of the china. M.V.K.

**Glazing on unfired bodies.** ANON. *Keram. Rund.*, **39** [17], 243–44 (1931).—Brief descriptions of the alterations necessary in composition, firing schedules, and specific gravities when changing from two-fire to one-fire ware are given. H.I.

**Plating porcelain with metals.** GEORG MASSOW. *Metallwaren-Ind. Galvano-*

*Tech.*, **30**, 14–16 (1932).—Methods of plating porcelain ware with Ag, Ni, and Cu are reviewed. (*C.A.*)

**Reversible expansion of clayware. XII.** TOSAKU YOSHIOKA. *Jour. Jap. Ceram. Assn.*, **38** [445], 1–27 (1930).—The thermal expansion of bodies and glazes of hard faience has been measured. Conclusions are as follows: (1) The temperatures at which the glazes practically solidify must be below 550°C. (2) The bodies should not show any irregularities at temperatures below 550°. (3) The bodies may contain quartz if its amount is small, because it favors the coincidence of contraction of the bodies and the glazes. **XIII.** *Ibid.*, **38** [446], 56–64 (1930).—Y. gives the results obtained in the experiments on the hydro-expansion of hard faience body and his considerations on the gradual crazing of its glaze. **XIV.** *Ibid.*, **38** [447], 148–55 (1930).—The results of experiments on the relation between the expansion of clays treated at high temperatures and their content of mullite are discussed. **XV.** *Ibid.*, **38** [450], 309–19 (1930).—The results obtained in the experiments on the thermal expansion of porcelain are presented. In general, the expansion of the bodies is low and even. If deficient in flux and fired strongly, they show an abnormal expansion at about 200°C. If they contain sufficient flux and are fired to the best degree, the temperature-expansion curves are straight and the coefficient is about 0.0000034. The coefficient is lowered with the rise of the firing temperature, reaching at last the minimum value as described above. The expansion of the glazes is even. Their softening temperatures are about 800°C. Marked difference in the expansion is observed between the body and glaze, but defects as seen in earthenware rarely occur. Strong heating of electric insulators improves their strength and increases their porosity as shown by the fuchsine test. **XVI.** *Ibid.*, **38** [454], 631–42 (1930).—The thermal expansion of various refractories has been measured. One of the purposes of making grog is to give the clay a low regular expansion. **XVII.** *Ibid.*, **38** [456], 783–87 (1930).—Experiments have been made on the expansion of some Japanese clays and similar raw ceramic materials. The materials have shown, regardless of their contents of quartz, a similar low straight expansion when they were fired at 1500°C for 1 hour. For Parts VII to XI see *Ceram. Abs.*, **10** [5], 361–63 (1931). S.K.

**Shrinkage changes in forming and drying white ware.** GERHARD BUDEWIG. *Keram. Rund.*, **39** [11], 157–58 (1931).—The changes in shrinkage for different thicknesses of the body were investigated for two whiteware clays, two experimental bodies, and two commercial bodies. When the thickness was changed from 3 to 7 mm. it caused a difference in shrinkage of 2.5%. The experiments showed that the shrinkage of the body was influenced by methods of working the clay, frictional resistance, and by absorptive power of the plaster molds. H.I.

**Firing difficulties in floor tile manufacture.** OTTO MUCKER. *Keram. Rund.*, **39** [15], 213–14 (1931).—The sticking-together of tile pieces in the kiln and the formation of large pores are due to too rapid a fire which does not permit the gases to escape before sintering begins and to close packing in the saggers blocking easy escape of water vapor and other gases. Cracks from corners to centers are ascribed to faulty pressing. S-shaped cracks showing vitreous fracture are cooling cracks. Other defects are mentioned and remedies are suggested. H.I.

**Low-tension porcelain insulators with wooden sockets.** A. D. BOGOSLOVSKI AND L. G. RESNIKOV. *Ceramics & Glass*, **8** [1], 38–41 (1932).—The production of low-tension porcelain insulators and the replacing of feldspar by nepheline are discussed. M.V.K.

**The electrotechnical product in porcelain manufacture.** ANON. *Chem. Trade Jour.*, **90** [2337], 227–28; [2338], 252–54 (1932).—A comprehensive discussion on compositions and properties of the porcelains is presented. M.V.K.

**Casting of porcelain insulators and casting house arrangements.** C. DORNEDDEN. *Keram. Rund.*, **39** [13], 183–86; [14], 202–204 (1931).—The plan of a convenient and economical casting house is described including suitable furniture, pumps, plaster molds, forms, etc. H.I.

**Large or complicated porcelain bodies for electrotechnical purposes.** O. NEUMANN. *Keram. Rund.*, **39**, 95 (1931).—Large porcelain bodies and those difficult to manufacture for use as insulators, conductors, condensors, etc., in high-tension and high-frequency lines are described and illustrated. H.I.

**Calculated loss in porcelain plants through defects in quality.** HEINRICH LANG. *Keram. Rund.*, **39** [9], 126–27 (1931).—Methods of calculating losses due to the production of seconds and scrap ware are given. The necessity for proper sorting and for discovering the source of defective ware is emphasized. H.I.

**Rockingham, the porcelain of Yorkshire.** ANON. *Arts & Dec.*, **37** [1], 36 (1932).—Illustrations and descriptions are given of Rockingham porcelain. E.B.H.

BOOK AND PAMPHLET

**Two Lectures on Architecture.** FRANK LLOYD WRIGHT. Art Institute of Chicago. 63 pp. 75¢. (*D.I.*)

**Twenty-Five Years Langenthal Porcelain.** ANON. Langenthal, Switzerland. Upon the occasion of the 25th anniversary of its foundation, the Langenthal porcelain factory published a pamphlet on its activity during a quarter of a century.

PATENTS

**Production of alumina, soda, and hydrochloric acid.** L. R. KEOGH (Soda Alumina Chemical Co.). U. S. 1,854,400, April 19, 1932. A process for the manufacture of alumina, sodium, carbonate, and hydrochloric acid from clay.

**Insulator.** J. A. DIENNER. U. S. 1,854,459, April 19, 1932.

**Tile roof construction.** E. G. MARTIN (T. D. Corcoran, M. W. Hard, and L. A. Wolff). U. S. 1,854,660, April 19, 1932.

**Wall tile covering.** HUBERT STÜKEN. U. S. 1,854,772, April 19, 1932.

**Preparation of feldspathic flux for porcelain.** C. H. PEDDRICK, JR., AND P. W. LEWIS (United Feldspar Corp.). U. S. 1,855,115, April 19, 1932.

**Toilet bowl.** FREDERICK PIPER. U. S. 1,857,328, May 10, 1932.

**Ceramic plates.** "KERAMAG" KERAMISCHE WERKE A.-G. Fr. 711,427, Feb. 18, 1931. Large ceramic plates are provided by molding or casting with a base in the form of a foot so that they can stand upright for drying and firing. The base is afterward removed. See also *Ceram. Abs.*, **11** [1], 49 (1932). (*C.A.*)

**Ceramic products.** I. G. FARBENINDUSTRIE AKT.-GES. Fr. 716,732, May 7, 1931. Ceramic products of great whiteness are obtained by treating the crude materials with Cl in a muffle furnace above 600°. The metallic chlorides are removed from the issuing gas, which is then used again. See also *Ceram. Abs.*, **11** [5], 316 (1932). (*C.A.*)

**Acid-resisting glazes.** DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER (Hermann Eisenlohr, inventor). Ger. 536,528, July 8, 1928. Glazes for ceramic ware containing basic constituents such as alkali, alkaline earths, and PbO and acid constituents such as $SiO_2$, $B_2O_3$, etc., are given an addition of FeO. The glazes are acid-proof. The glaze preferably contains 1 to 2 mol. $SiO_2$ and 0.1 to 0.4 mol. $B_2O_3$. The glaze mentioned in the example contains 0.8 PbO, 0.1 $Na_2O$ or $K_2O$, 0.1 FeO, 1.5 $SiO_2$, and 0.4 $B_2O_3$. (*C.A.*)

**Annealing high-voltage insulators.** A. T. GELMAN AND E. G. SOLOV'EV. Russ. 19,518, Feb. 28, 1931. (*C.A.*)

## Equipment and Apparatus

**P.C.E. furnace for high temperatures.** VANCE CARTWRIGHT AND STUART M. PHELPS. *Brick Clay Rec.*, **80** [4], 205 (1932).—A new type P.C.E. furnace designed to burn either artificial or natural gas or propane is described. Illustrated. See also *Ceram. Abs.*, **10** [2], 130 (1931). E.J.V.

**Use of metals at elevated temperatures.** CLYDE E. WILLIAMS. *Brick Clay Rec.*, **80** [4], 195–97 (1932); *Ceram. Ind.*, **18** [5], 308–10 (1932).—W. considers the heat requirements of metals used in kiln construction, in drier car construction, in fans and blowers, for flues and ducts for transmitting hot air, in nozzles, and in doors and walls of tunnel driers. Illustrated. E.J.V.

**Temperature control closet for adiabatic calorimetry.** B. C. HENDRICKS AND W. H. STEINBACH, JR. *Jour. Phys. Chem.*, **36** [4], 1279–81 (1932).—Details of construction and operation are given. Illustrated. G.R.S.

**Combustion indicator.** ANON. *Chem. Met. Eng.*, **39** [3], 163 (1932).—Automatic indication of furnace conditions is provided by the Hays automatic combustion indicator. This instrument is a mechanical Orsat apparatus. In addition to indicating $CO_2$, the instrument may be equipped to indicate various combinations of flue-gas temperature and draft at one or more points. G.R.S.

**Works and laboratory control of the moisture content of ceramic pastes.** P. P. BUDNIKOFF AND V. J. ENDOVITZKY. *Chem.-Ztg.*, **56**, 47–48 (1932); for abstract see *Ceram. Abs.*, **10** [11], 813 (1931). (*B.C.A.*)

**Apparatus for evaporation of various materials in high vacua.** C. HAWLEY CART-

WRIGHT AND JOHN STRONG. *Rev. Sci. Instruments*, **2** [3], 189–93 (1931); see also *Ceram. Abs.*, **10** [6], 418 (1931). H.I.

**Science and practice of drying. XIII.** ANON. *Brit. Clayworker*, **40** [480], 4–6 (1932).—The efficiency of the chamber drier is discussed. The inverse current driers introduced by Hoffman, the Proctor drier, and the Boss drier are described. For Part XII see *Ceram. Abs.*, **11** [6], 379 (1932). R.A.H.

**Tunnel driers with moving charges. III.** CARL LOESER. *Sprechsaal*, **65** [13], 235–39 (1932).—L. calculates the costs of the erection of a tunnel-drying installation with moving charges and points out the economies and advantages obtained in the operation of the plant. For Part II see *Ceram. Abs.*, **11** [4], 255 (1932). M.V.K.

**Waste heat for brick drying.** W. LEDER. *Tonind.-Ztg.*, **56** [25], 347–49 (1932).—Calculations are given for the number of green brick that may be dried by using the waste heat of 10,000 brick or the waste heat of a 60 h.p. steam engine. W.M.C.

**Relation between tile die bridges and drier cracks.** EDWARD RODDEWIG. *Brick Clay Rec.*, **80** [4], 202–203 (1932).—Several different types of dies were studied. Illustrated. E.J.V.

**Determination of the size of suspensoid particles: Brief review of methods and a modified form of apparatus.** NORVAL BEEMAN. *Lingnan Sci. Jour.*, **8**, 625–36 (1929).—A modification of the Kelly apparatus for measuring the size of suspended particles is described. (*C.A.*)

**Screen control of closely sized abrasives.** HENRY R. POWER. *Metal Cleaning & Finishing*, **4** [4], 241–42 (1932).—Data on tests using different sets of bronze wire-cloth screens and on several sets of samples of abrasives are presented. Illustrated. E.J.V.

**Stedman Quadrex vibrating screen.** ANON. *Clay-Worker*, **97** [4], 218 (1932).—Illustrated. E.J.V.

**Performance characteristics of cyclone dust collectors.** L. C. WHITON, JR. *Chem. Met. Eng.*, **39** [3], 150–51 (1932); for abstract see *Ceram. Abs.*, **11** [5], 317 (1932). G.R.S.

**Glass-wool filter.** OWENS-ILLINOIS GLASS CO. *Chem. Met. Eng.*, **39** [3], 166 (1932); *Nat. Glass Budget*, **48** [1], 5 (1932).—"Dustop" consists of a paper container packed with a 2-in. thickness of glass wool which has 99% dust collection efficiency. G.R.S.

**Pivot mounting in pyrometers.** ANON. *Chem. & Ind.*, **51** [15], 316–17 (1932).—Troubles and inaccuracies due to damaged pivots in pyrometer indicators are discussed. The only known form of universal springing, called "Resilia," is shown in a diagram. Resilia successfully withstood tests which put all the other systems out of action. G.R.S.

**Fork lift truck.** ANON. *Chem. Met. Eng.*, **39** [3], 165 (1932).—A pair of chisel-pointed forks replace the usual lift platform on a new 6000-lb. capacity electric lift truck. G.R.S.

**Use of small tractor shovels.** C. E. KOHL. *Brick Clay Rec.*, **80** [4], 222 (1932).—Illustrated. E.J.V.

**Progress in the modern ceramic industry.** G. COLIEZ. *Rev. ind.*, **61**, 620–28, 676–81 (1931).—Plant and equipment used in the ceramic industry in France and Germany are illustrated and described. (*C.A.*)

**Maintenance of machinery in brick plants.** ANON. *Tonind.-Ztg.*, **56** [30], 395–97 (1932).—Different types of steel coatings for extruding and crushing machines are reviewed. W.M.C.

**Grinding and sifting.** F. DE M. TUBMAN. *Chem. & Ind.*, **51** [16], 330–37 (1932).—Roller mills, hammer, attrition, ball, and tube mills, and oscillating and gyrating sieves are discussed. G.R.S.

**Apparatus for cutting brick, etc.** P. RENAULT. *Rev. mat. constr. trav. pub.*, No. 270, pp. 48–52*B* (1932).—Different types of French and German mills and molding apparatus are described. See also *Ceram. Abs.*, **11** [6], 368 (1932). M.V.K.

**Automatic batch controlling device.** TOLEDO PRECISION DEVICES, INC. *Glass Ind.*, **13** [5], 92 (1932); *Ceram. Ind.*, **18** [5], 322–24 (1932).—A Toledo scale equipped with a photoelectric tube is described and illustrated. E.J.V.

**New flowerpot machine.** L. J. FRIEDL. *Brick Clay Rec.*, **80** [4], 210–11 (1932); *Ceram. Ind.*, **18** [5], 314–15 (1932).—Illustrated. E.J.V.

BULLETINS

**Liquid-oxygen explosives.** G. ST. J. PERROTT AND N. A. TOLCH. Bur. Mines *Bull.*, No. 349. 88 pp. 36 illus. 25¢ from Supt. Documents, Govt. Printing Office, Washington, D. C. See also *Ceram. Abs.*, **9** [3], 235 (1930). R.A.H.

**Crushing and grinding limestone at the Howes Cave (N. Y.) plant of the North American Cement Corp.** W. J. FULLERTON AND A. W. COX. Bur. Mines *Information Circ.*, No. 6553. 7 pp. (Free.) See also *Ceram. Abs.*, **11** [2], 124 (1932). R.A.H.

PATENTS

**Art of shipping or transporting hollow tile, brick, gypsum blocks, pipe, etc.** N. G. CAMPBELL AND J. J. YATES (Newark Warehouse Co.). U. S. 1,855,665, April 26, 1932.

**Drive for presses for shaping tile, etc.** F. G. GATENSBURY. U. S. 1,856,096, May 3, 1932.

**Apparatus for drying clay.** R. J. VARCOE. Brit. 370,102, April 13, 1932.

**Furnace for drying ceramic products.** KARL LÜHMANN. Fr. 710,798, Feb. 7, 1931. (*C.A.*)

**Apparatus for estimating the degree of fineness of natural dust and ground materials.** FIRMA GEORG ROSENMÜLLER. Ger. 537,810, June 7, 1930. (*C.A.*)

## Kilns, Furnaces, Fuels, and Combustion

**Combustion of some gaseous and solid fuels.** T. J. ESS. *Heat Treating & Forging*, **17**, 387–90 (April, 1931); *Blast Fur. Steel Plant*, **19**, 704–707 (May, 1931).—The combustion of blue water gas, oil gas, carbureted water gas, town gas, liquefied gases, colloidal fuel, and briquetted fuel is discussed. See also *Ceram. Abs.*, **10** [6], 451 (1931). (*J.I.S.I.*)

**Application of X-rays to the petrography of coal.** H. WINTER. *Glückauf*, **67**, 1105–11 (Aug., 1931).—The application of X-rays to the petrography of coal gives a picture of the condition and distribution of the ash; to obtain useful quantitative figures, however, certain assumptions must be made. The measurement of the strength of the ionization current by means of a gold-leaf electroscope and an ionization chamber is a more exact method. More rapid results are obtained by the instrument used by W. For an accurate determination of the ash, its chemical structure must be considered. The efficiency of coal- and coke-cleaning processes can be immediately determined by means of X-rays, whereas the simple determination of the ash content would require at least one or two hours. (*J.I.S.I.*)

**Data. VI.** T. W. GARVE. *Clay-Worker*, **97** [4], 206–207 (1932).—G. takes up a discussion of gas producers, properties of producer gas, heat value of various fuels, heat emission to be expected from different types of radiators, heat loss, and the transmission coefficient of different materials. For Part V see *Ceram. Abs.*, **11** [6], 368 (1932). E.J.V.

**Coal.** H. A. CURTIS. *Chem. & Ind.*, **51** [17], 350–55 (1932).—The macro- and micro-structures of coal are dealt with. The origin, chemistry, and carbonization of coal are treated, and the problem of characterizing coal by numerical values is discussed. G.R.S.

**Comparative values of heat in coal, oil, and gas.** S. H. VIALL. *Chem. Met. Eng.*, **39** [4], 234 (1932).—Two charts are given with directions for their use. G.R.S.

**Glass plant fuel oil.** JOHN W. ROMIG. *Glass Ind.*, **13** [5], 79–81 (1932).—Test equipment for car lot testing and portable equipment for small lot tests of fuel oil are described. Illustrated. E.J.V.

**Use of natural gas in firing structural clay products.** MARION W. BLAIR. *Clay-Worker*, **97** [4], 220 (1932); see *Ceram. Abs.*, **11** [5], 304 (1932). E.J.V.

**Use of cheaper fuels.** A. JAESCHKE. *Keram. Rund.*, **39** [11], 153–57 (1931).—Economical and efficient methods of using sawdust, wood shavings, lignite, and peat are considered and sketches of kilns are shown which are especially suitable for using these fuels as fine powders, briquets, or as semiproducer gas installations. H.I.

**Electrical heating.** J. A. LEE. *Chem. Met. Eng.*, **39** [4], 223–25 (1932).—The advantages of electrical heating are outlined for glass troughs and leers, continuous kilns for wall tile, abrasives, and for drying and preliminary baking of grinding wheels. G.R.S.

**Report of the Fuel Research Board.** ANON. *Engineering*, **133** [3448], 192–93 (1932); for abstract see *Ceram. Abs.*, **11** [6], 385 (1932). A.A.

**Waste heat in kilns.** WILLIAM A. BUTLER. *Clay-Worker*, **97** [4], 211 (1932).—Waste heat from different types of kilns is classified and its uses are discussed. E.J.V.

**Tunnel kilns. II.** RENÉ SYLVANY. *Rev. mat. constr. trav. pub.*, No. 270, pp. 43–46*B* (1932).—S. discusses the general characteristics of electric tunnel kilns and the

operation of the Moore-Kampbel kiln for firing enamel and for firing decorations on pottery. The development of these kilns and their advantages over other systems are given. For Part I see *Ceram. Abs.*, **11** [6], 382 (1932). M.V.K.

**New kilns.** ERNST ASTER. *Feuerungstechnik*, **20** [4], 56–60 (1932).—A. describes different kinds of new industrial and laboratory kilns and different measuring and controlling apparatus shown at the Leipzig Fair in 1932. M.V.K.

**Thermal insulation of furnaces and kilns.** A. E. HUBBARD. *Fuel Econ.*, **6**, 546–56 (1931).—Heat balances of typical high-temperature furnaces and kilns are tabulated. Heat losses by radiation and convection are briefly referred to, and the effects and advantages of insulation are briefly discussed. (*J.I.M.*)

PATENTS

**Carbureting nozzle for burning powdered coal.** W. L. MCLAUGHLIN AND H. L. MCLAUGHLIN (E. L. Twining). U. S. 1,856,134, May 3, 1932.

**Temperature-control method for ceramic furnaces or kilns.** A. S. WATTS. U. S. 1,857,702, May 10, 1932. Controlling the heating action by abrupt temperature changes by means of the ventilation of the chamber in which the ware is located, decreasing the ventilation for the development of higher temperatures, and increasing the ventilation for lowering of temperatures.

**Tunnel kiln.** E. B. FORSE AND C. F. GEIGER (Carborundum Co.). U. S. 1,858,008, May 10, 1932.

**Electric furnace.** ALFRED RUCKSTAHL (Holcroft & Co.). U. S. 1,858,062, May 10, 1932.

**Ovens for firing pottery and enamel goods and for the heat-treatment of metals, etc.** GIBBONS BROS., LTD., AND M. VAN MARLE. Brit. 370,087, April 13, 1932.

**Electric heating elements for kilns.** S. D. WHITE AND V. O. CUTTS. Brit. 371,158, April 27, 1932.

**Firing hollow articles of refractory, insulating, or abrading material.** MARCEL FOURMENT. Fr. 638,843, Dec. 21, 1926; Ger. 541,139, Jan. 5, 1927. An apparatus for heating refractory, insulating, and abrading materials by induction currents at high frequency is described. (*C.A.*)

**Annular canal muffle furnace.** WOODALL-DUCKHAM, LTD., AND A. MCD. DUCKHAM. Ger. 537,597, Aug. 2, 1927. (*C.A.*)

**Ceramic ware.** W. TAYLOR AND J. M. TEAHEN. Ger. 539,825, Feb. 5, 1929. Details of firing are given. (*C.A.*)

**Circular five-chamber brick kiln.** A. S. FILIPPOV. Russ. 19,517, Feb. 28, 1931. (*C.A.*)

**Annular kiln.** A. G. W. BERN. Swed. 69,003, March 4, 1930. (*C.A.*)

**Tunnel-like brick or tile kiln.** VOJECH LAŠTOVIČKA. Swiss 147,376, March 27, 1930; see also *Ceram. Abs.*, **10** [8], 596 (1931). (*C.A.*)

## Geology

**Constitution of diatomaceous earth.** ANON. *Ind. chimique*, **19** [216], 65 (1932).—The constitution of diatomaceous earth varies considerably according to the manner in which the deposits are formed. Several kinds are described. M.V.K.

**Rare earths.** C. BERTHELOT. *Mines et Carrieres*, October, 1930; *Ind. chimique*, **18** [212], 640 (1931).—B. describes the deposits and the treatment of the principal rare earths of the series of ytrium, thorium, cerium, lanthanum, didymium, etc. (1) Monazite is a mineral consisting of a mixture of phosphate of cerium, lanthanum, thorium, didymium, and ytrium. It is a constituent of beach sand and its value depends on the quantity of thorium oxide present. (2) Cerium oxide forms the final residue of the rare earths after the elimination of thorium oxide. Considerable quantities of these compounds are used for preparing special glasses, such as Crooke's pipes. (3) Mesothorium is a substance having properties resembling those of radium. It is a by-product in the production of thorium nitrate. When combined with zinc sulphide, it is used for the preparation of compounds which are luminous in the dark. (4) Ilmenite is a titanate of iron used for the extraction of titanium oxide for white colors. M.V.K.

**Possible industrial applications for bentonite.** HUGH S. SPENCE AND MARGARET LIGHT. *Can. Dept. Mines, Mines Branch Rept.*, **723**, 12–34 (1931).—An annotated list of 250 patents covering the use of bentonite and a bibliography of 59 references published since 1924 are listed by uses. (*C.A.*)

**Utilization of nepheline in Russia.** ANON. *Chem. Trade Jour.*, **90** [2337], 226 (1932).—The mineral nepheline which contains about 44% silica, 34% aluminum oxide, and 22% alkali metal, has been found in considerable quantities in the Kola peninsula in north Russia. Nepheline, on heating to 1300° with lime, decomposes with the separation of the alkalis and the alumina and with the formation of a calcium silicate which can be used for the cement industry. By the action of carbon dioxide, the alkalis and alumina can be separated. The mineral can also be decomposed by sulphuric acid or sulphur dioxide for the production of potash soda alum and alkali sulphites, in addition to basic aluminum salts and hydrated silica. Nepheline itself is being used in the undecomposed condition in the glass industry in place of soda and in the ceramic industry in place of feldspar. The presence of iron impurities in the mineral militates against its employment in other than bottle glass. See also *Ceram. Abs.*, **10** [11], 762; [12], 832 (1931). M.V.K.

**Determination of the colloid content of certain Tennessee ceramic clays.** J. B. BOND, JR. *Jour. Tennessee Acad. Sci.*, **5**, 5–8 (1930).—By the soil colloid hydrometer method the colloid contents of many ceramic clays selected from various parts of the state were found to be within the range 30 to 60%. (*C.A.*)

**Principles of the genetic formation of materials. III. Chemistry and morphology of aluminum hydroxide.** V. KOHLSCHÜTTER, W. BEUTLER, LENELORE SPRENGER, AND MAX BERLIN. *Helv. Chim. Acta*, **14**, 3–49 (1931). **IV and V.** V. KOHLSCHÜTTER AND W. BEUTLER. *Ibid.*, **14**, 305–30; 330–45 (1931). (*C.A.*)

BOOKS AND BULLETINS

**Principles of Structural Geology.** C. M. NEVIN. xii + 304 pp. John Wiley, New York, 1931. Price $4.60. Reviewed in *Geographical Jour.*, **79**, 65 (1932). H.H.S.

**Applied Geophysics.** H. SHAW, J. McG. BRUCKSHAW, AND S. T. NEWING. Price 2s. Reviewed in *Geographical Jour.*, **79**, 62–63 (1932); see also *Ceram. Abs.*, **10** [8], 599 (1931). H.H.S.

**Lawrence Clay of Lawrence County.** W. STOUT, M. C. SHAW, G. A. BOLE, AND D. SCHAAP. 4 plates, 22 figures, 1 map. *Geol. Surv. Ohio*, Series 4, *Bull.*, No. 36, 134 pp. (1932); for abstract see *Ceram. Abs.*, **11** [5], 323 (1932).

**Geophysical Abstracts. XXXV.** F. W. LEE. Bur. Mines *Information Circ.*, No. 6606. 29 pp. (Free.) The report reviews current articles on geophysical methods and includes a bibliography of new books published. For Part XXXIV see *Ceram. Abs.*, **11** [6], 387 (1932). R.A.H.

**Talc and soapstone in 1930.** OLIVER BOWLES AND B. H. STODDARD. Bur. Mines *Mineral Resources U. S.* 11 pp. 5¢. R.A.H.

## Chemistry and Physics

**Notes on electrometric iron determination: Iron in feldspar.** A. K. LYLE, JR. *Jour. Amer. Ceram. Soc.*, **15** [6], 334–37 (1932).

**Physico-mechanical analysis of sands.** A. GUÉDRAS. *Aciers Spéciaux*, **6**, 239–42 (May, 1931).—The xylene-distillation method of estimating the moisture in sand and a sedimentation method for determining the silica, clay, and colloids are described. (*J.I.S.I.*)

**Gel formation and thixotropy in some Danish clay types.** ALICE JEPPESEN. *Kolloid-Z.*, **57** [2], 175–80 (1931).—Suspensions of four highly plastic Danish clays were made to solidify like gels without addition of any electrolytes within different but broad ranges of concentrations. The solid formation showed thixotropic properties. The coagulation relations were investigated and it was found that only suspensions which previously coagulated would become solid. When coagulation was slow gel formation took place in lower concentrations than when coagulation was rapid. This was probably explained by favorable swelling characteristics in the former case. The swelling was explained by the flaky structure of the primary particles in combination with the type and amount of adsorbed cations ($Na^+$ and $K^+$). H.I.

**"Single-value" soil constants: A study of the significance of certain soil constants. VI. Changes produced in a soil by exposure to high temperature.** J. R. H. COUTTS. *Jour. Agric. Sci.*, **22** [1], 200–202 (1932).—C. heated four different types of soils in an electric furnace to just below 1000°C and found that the loss on ignition is not affected by changes in the temperature of the furnace above 600°C. Errors in the

determination are of the order of 1% of the true value. He ascribes the loss in weight of the soils to loss of free and interstitial water up to 100°C, to destruction of organic colloids between 100 and 250°C, and to the destruction of inorganic colloids at higher temperatures. **VII. Moisture equivalent and some related quantities.** *Ibid.*, **22** [1], 203–11 (1932).—Sixty-four soil samples from Natal were treated by saturating, running 40 min. in a special centrifuge, and then determining the loss of weight by drying for 24 hr. in an oven at 105°C. The xylene equivalent of the Natal soils was also measured and the imbibitional water calculated from the two equivalents and the specific gravity of the soil. Equations giving the moisture equivalent and the xylene equivalent in terms of their loss on ignition and mechanical composition are obtained and the significance of the relative values of the numerical coefficients in these equations is discussed. For Parts I–V see *Ceram. Abs.*, **11** [6], 389 (1932). J.L.G.

**Water determination by the xylol method in ceramic plant laboratories.** FRITZ ECK. *Keram. Rund.*, **39** [15], 215–16 (1931).—The xylol method may be used satisfactorily on clay, sand, etc., as well as on fuels. As compared with the method of drying at 110°C the xylol method requires only 48 min. compared with 2 hr. 7 min. H.I.

**Study of mullite. I.** TOSAKU YOSHIOKA AND MINEZO ISOMATSU. *Jour. Jap. Ceram. Assn.*, **38** [448], 200–208 (1930).—The results of experiments on the quantitative separation of mullite in fired clays are as follows: (1) If mullite is treated with an excess of 40% HF solution for 24 hr., as in the methods reported hitherto, the greater part is probably dissolved, sometimes leaving only 5% undissolved. (2) When mullite is treated with 20% solution at about 30°C for 24 hours, the greater part is dissolved and in some cases only 10% is left. (3) Bakelite vessels have been satisfactorily used for the experiments. **II.** *Ibid.*, **38** [455], 705–10 (1930).—Experiments have been made of the determination and formation of mullite. Quartz and fused silica, ground to pass 200-mesh, dissolve practically completely in 6 hr. in an excess of 40% HF solution at 0°. Alundum does not dissolve under practically the same conditions. Under the same conditions 86% of mullite remains undissolved. About 0.5 g. of the sample, ground to pass 200-mesh, is placed in a bakelite test tube and 8 cc. of 40% HF solution are added. The tube is placed in ice water for 6 hr. and is shaken from time to time. The contents are transferred to a beaker containing water and the precipitate is washed, dried, and ignited. The amount is the safe yield and this, multiplied by $^{100}/_{86}$, is the presumptive yield. The effects of the temperature and flux on the formation of mullite are discussed. Aluminium hydroxide was added to a clay to raise the ratio $Al_2O_3$:$SiO_2$ to 3:2. One per cent flux was added to the mixture and the sample was heated for 1 hr. at 1400°C.

Residue or Safe Yield of Mullite

| Flux | $Fe_2O_3$ | $CaF_2$ | $B_2O_3$ | Orthoclase | Steatite | Talc | CaO |
|---|---|---|---|---|---|---|---|
| Residue (%) | 83.4 | 79.7 | 85.0 | 81.4 | .83.0 | 81.7 | 80.3 |

Thus, nearly theoretical yield has been given with some fluxes. S.K.

**Determination of the size of loose particles.** A. H. M. ANDREASEN. *First Communications New Internat. Assn. Test. Materials*, [*D*], 156–60 (1930).—The size of a particle, $k$, is defined as the length of the side of a cube of equal volume. The average size of a particle in a mass of matter is determined most accurately by counting the particles in a given quantity of the material. For this purpose a suspension of from 2 to 0.02 g. of the mass to be investigated is introduced into a measured quantity (about 500 g.) of glycerin in a counting chamber with a base area of 256 cm.$^2$ After the particles have settled, an exact fraction of the surface, containing 100 to 200 particles, is counted by means of a grid micrometer. The mean size of particle, $k_m$, of a mass selected between the limits $k_1$ and $k_2$ is given by the formula

$$k_{m\,k_1-k_2} = \sqrt[3]{2\,\frac{k_1^2 \times k_2^2}{+\,k_2\,k_1}}$$

The mesh, $D_m$, of a sieve corresponding to this size of particle is given by

$$D_{m\,d_1-d_2} = \sqrt[3]{2\,\frac{D_1^2 \times D_2^2}{D_1 + D_2}}$$

if $D_1$ and $D_2$ are the meshes corresponding to the sizes of particle $k_1$ and $k_2$. The ratio $k_m/D_m$ for all common ground substances and for sieves of uniform mesh is within

the limits 0.8 and 0.9. The differences between the calculated and experimental values for mean size of particle have not exceeded 3% in investigations hitherto carried out. See also *Ceram. Abs.*, **11** [4], 282 (1932). (*J.I.M.*)

**Plasticity of clay.** SEIJI KONDO AND AKITARO MANNAMI. *Jour. Jap. Ceram. Assn.*, **38** [453], 537–39 (1930).—Experiments have been made on Bancroft's test for the plasticity of clay. The results indicate that the method is fairly promising and also that it is better to dry the balls completely than to use air-dry balls as the humidity of air is very high in Japan. S.K.

**Replacement of the constituents in Seger's formula of a cone 8 porcelain glaze.** ITSUO YAMAZAWA. *Jour. Jap. Ceram. Assn.*, **38** [446], 65–71 (1930).—Each constituent of a cone 8 porcelain glaze was replaced by other oxides. The replacement was done by equivalents as well as by weight. Most of the glazes prepared by replacing CaO and $SiO_2$ by equivalent amounts of other RO and $RO_2$, respectively, were worthless, satisfactory results having been given only in those cases where the replacement took place with similar weight. The replacement by weight gave better results. Y. concludes, therefore, that the method of expressing glaze formulas with weight ratios may be more effective than the usual method. S.K.

**Measurement of fine particles of cement by means of an air analyzer. I.** MITSUZO FUJII. *Jour. Jap. Ceram. Assn.*, **39** [468], 788–801 (1931).—The grain size and the range of application of Stokes' law are discussed mathematically. **II.** *Ibid.*, **40** [469], 5–13 (1932).—The results obtained with H. W. Gonell's air analyzer and the conversion ratios of Asano's diameters, Goldstein's diameters, etc., are given. Some of the results are as follows:

| Asano diameter in $\mu$ | 0 – 9.9 | 9.9 –19.4 | 19.4 –28.7 | 28.7 –42.6 | 42.6 –60.5 | 60.5 –91.7 | (4900 M.R.) > 91.7 |
|---|---|---|---|---|---|---|---|
| Jap. Portland cement (%) | 24.9 | 16.0 | 14.5 | 16.7 | 15.7 | 10.3 | 2.4 |
| Asano Velo cement | 35.0 | 19.3 | 13.7 | 13.9 | 10.4 | 4.9 | 2.8 |
| German Portland cement | 26.4 | 15.1 | 11.0 | 12.7 | 11.5 | 13.0 | 10.3 |

*Conclusions:* (1) Goldstein's formula must be used for the analysis because the important range for cement particles is from about 0 to 60$\mu$. (2) The ratio of the theoretical diameter to the measured diameter is constant for each of the diameters by Asano ($\sqrt[3]{\text{ft.}}$), Guttmann ($\sqrt{f}$), and the Bureau of Standards (D). Thus, any of the three definitions may be used. Guttmann's diameter, however, seems to be most favorable since it is very near to Goldstein's diameter and is convenient in the measurement. S.K.

**Surface chemistry of hydrates. II. Decomposition without lattice rearrangement.** V. R. DAMERELL, F. HOVORKA, AND W. E. WHITE. *Jour. Phys. Chem.*, **36** [4], 1255–67 (1932).—Alumina trihydrate loses water at ordinary temperatures by a surface dehydration in which the remaining lattice structure does not appreciably rearrange. A tentative dehydration theory is advanced. The methods employed by Willstätter and co-workers to identify hydrates are criticized as giving doubtful results in the case of gels and precipitates of small particle size. For Part I see *Ceram. Abs.*, **10** [6], 461 (1931). G.R.S.

**Extinction coefficients of the silicic acid gel-forming mixtures.** M. PRASAD, S. M. MEHTA, AND J. B. DESAI. *Jour. Phys. Chem.*, **36** [4], 1324–36 (1932). G.R.S.

**Determination of adhesion tension of liquids against solids. A microscopic method for the measurement of interfacial contact angles.** F. E. BARTELL AND E. J. MERRILL. *Jour. Phys. Chem.*, **36** [4], 1178–90 (1932).—The adhesion tension as measured is specific and definite for a given solid-liquid system. G.R.S.

**Chemical activity and particle size. II. Rate of solution at slow stirring of anhydrite and gypsum.** P. S. ROLLER. *Jour. Phys. Chem.*, **36** [4], 1202–31 (1932).—The relative rate of solution of fractions in water was determined by conductivity measurement at 20°C at a stirring speed of 130 r.p.m. A discussion is given of the theory that solution takes place from active centers which involve the edges and corners of a crystal. For Part I see *Ceram. Abs.*, **10** [6], 458 (1931). G.R.S.

**Dissociation of lithium carbonate and potassium carbonate.** J. T. HOWARTH AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **15** [60], 360–64 (1931).—The melting points of lithium, sodium, and potassium carbonates are 618, 851, and 891°C, respectively. The interval between the melting point and the temperature at which the dissociation pressure is 1 mm. is about 130° for $Li_2CO_3$ and $Na_2CO_3$, but it is substantially shorter for $K_2CO_3$. See also *Ceram. Abs.*, **10** [7], 525 (1931). G.R.S.

**Electrochemistry of colloids, its industrial applications.** PAUL BARY. *Bull. soc.*

*encour. ind. nat.*, **130**, 517–47 (1931).—A review of interrelations of electrochemistry and colloids is given with a general discussion of accumulators, clay industries, emulsions, rubber, peat drying, demineralization of gelatin, and purification of water. (*C.A.*)

**The viscosity of suspensions.** J. DUCLAUX AND D. SACHS. *Jour. chim. phys.*, **28**, 511–16 (1931).—Particles of silicon carbide of the order of 0.2 to 0.3$\mu$ in suspension were studied in order to determine whether or not unsolvated particles, irregular in shape, give the coefficient 2.5 to 2.9 in the Einstein equation relating viscosity and concentration wherein the particles are assumed to be perfect spheres. The mean value of 19.2 obtained is believed due entirely to irregular surfaces which cause turbulence in the liquid medium. $PbI_2$ in suspension, although known to give lamellar grains, gave results of 4.6 and 5.9 for the coefficient, depending on the concentration. (*C.A.*)

**Analysis of refractory materials.** C. PERTUSI AND E. DI NOLA. Abstracted in *Refrac. Jour.*, **8** [4], 160 (1932); for abstract see *Ceram. Abs.*, **11** [6], 392 (1932). E.P.R.

**Amphoteric oxide hydrates and their aqueous solutions and crystalline compounds. Silicic acids and dissolved silicon oxide hydrate in alkaline and acid solutions.** GERHART JANDER AND WILHELM HEUKESHOVEN. *Z. anorg. allgem. Chem.*, **201** [3], 361–82 (1931).—The authors have studied alkaline silicate solutions of different $p_H$ by methods described previously (diffusion, optical absorption, etc.). In aqueous alkali-silicate solutions only anions of a mono- or di-silicic acid are stable, depending on the $p_H$ and according to the equation, $2SiO_3^= + H_2O = Si_2O_5^= + 2OH^-$. The ranges of $p_H$ in which these anions are stable are given. L.T.B.

**Determination of aluminum and excess acid in aluminum salts.** H. L. DAVIS. *Jour. Phys. Chem.*, **36** [5], 1449–53 (1932).—The earlier work on the volumetric determination of aluminum in solutions of its salts was extended to include a similar method for the excess acid sometimes found in such solutions. Using thymol blue as the indicator it was shown to be possible to titrate first the excess acid and then the aluminum present in a sample salt. If the salt is a basic salt then a portion of a known excess of standard acid will be used in correcting this and the remainder will be titrated by the method. The determination of sodium oxide and of alumina present in a sodium-aluminate solution can be made similarly by the use of the same indicator. See also *Ceram. Abs.*, **11** [5], 327 (1932). G.R.S.

**Diagram of equilibrium of the system PbO–$SiO_2$.** K. A. KRAKAU AND N. A. VAKHRAMEEV. *Trans. State Optical Inst.* [Leningrad], Vol. 70; *Ceramics & Glass*, **8** [1], 42–43 (1932).—The melting diagram of the PbO–$SiO_2$ system in the limits from 0 to 72% mol $SiO_2$ was investigated by three methods: (1) thermal study of the cooling curves, (2) thermal study of the heating curves, and (3) optical study of the crystals formed. On the basis of the first two methods and with the help of the static method, the general course of the curve was obtained. The studies of the diagram of melting showed that the orthosilicate $2PbO \cdot SiO_2$ and the metasilicate $PbO \cdot SiO_2$ exist as definite chemical compositions and crystallize, the former at 746° and the latter at 765°. A polymorphic conversion exists at 620° for the orthosilicate $2PbO \cdot SiO_2$. A eutectic exists between the ortho- and meta-silicates of lead at a temperature of about 700°. The crystal optical investigations showed the existence of the silicate $3PbO \cdot SiO_2$, which is in a metastable state at temperatures lower than 690°. The compounds $3PbO \cdot SiO_2$ also form eutectics. The silicate $PbO \cdot SiO_2$ has a eutectic with silica at about 700°. Data on the optical properties of the compounds formed are given. Forms of tridymite and cristobalite were found during the crystallization of silicates from glasses containing 60 to 70% silica. Two kinds of thermal effects appearing during the heating of glasses were observed during the study of the PbO–$SiO_2$ system in the vitrified state: (1) the exothermic effect connected with the molecular conversion into the vitrified state, and (2) the endothermic effect connected with the crystallization of definite compounds. M.V.K.

**Engler viscometer and the theory of laminar flow at the entrance of a tube.** L. SCHILLER. *Jour. Rheol.*, **3** [2], 212–16 (1932).—Measurements and calculations were made to determine whether or not the relationship between kinematic viscosity $\nu$ and Engler degrees, $E$, is adequately represented by Vogel's empirical equation. G.R.S.

**Critical constants and vapor pressure of boron trifluoride.** H. S. BOOTH AND J. M. CARTER. *Jour. Phys. Chem.*, **36** [5], 1359–63 (1932).—Critical temperature of boron trifluoride is −12.25°C ± 0.03°, and the critical pressure is 49.2 atmospheres (I.C.T. normal) ± 0.1 atmosphere. The equation for the vapor pressure was found to be $\log_{10}P = 5.1009 - 0.8896.1000/T$. G.R.S.

**Future problems of theoretical rheology.** M. D. HERSEY. *Jour. Rheol.*, **3** [2], 196–204 (1932).—A brief sketch or review is given of some of the older and newer problems of rheology, indicating various methods of attack, and is intended to stimulate further research. G.R.S.

**Outline of a systematic survey of rheological theories.** M. PEINER. *Jour. Rheol.*, **3** [2], 245–56 (1932). G.R.S.

**Approximate calibration of apparatus for measuring absolute viscosity.** C. H. WEISS AND M. LOUIS. *Jour. Rheol.*, **3** [2], 217–20 (1932).—The utilization of standard liquids for calibrating viscometers is discussed. G.R.S.

**Determining sulphuric acid in clay.** T. SCHUMANN. *Sprechsaal*, **65** [13], 240 (1932).—A 200-mesh sample is rapidly heated to 800°C in crucibles, cooled and thoroughly "dissolved" in a percolator which is described, and filtered; the sulphuric acid is determined in the filtrate. If large quantities of gypsum are present, it is recommended to convert the calcium salt into the more soluble ammonium sulphate by means of ammonium carbonate. Much higher values are found when using this method. M.V.K.

**Composition, properties, and applications of some minerals in the building, refractory, and ceramic industries. II.** JOSEPH DEFORGE. *Rev. mat. constr. trav. pub.*, No. 270, pp. 52–55*B* (1932); for Part I see *Ceram. Abs.*, **11** [6], 371 (1932). M.V.K.

**Rapid determination of silica, alumina, and iron oxide in cement.** G. BAIRE. *Ind. chimique*, **18** [213], 699 (1931).—The mixture is decarbonated, cooled, and pulverized. One gram is moistened with water and acetic acid, heated to dryness on a sand bath, taken up again with water, and dilute nitric acid is added until the reddish color disappears. It is then boiled, filtered, and washed. The precipitate is calcined and weighed. Hydrochloric acid is added to the filtrate, boiled, and neutralized with ammoniac in excess to precipitate the alkaline oxides. A second sample for determining iron is treated with sulphuric acid, reduced with zinc, and titrated. Alumina is determined from the difference. M.V.K.

**Ceramic tables for the use of calculators.** ANON. *Keram. Rund.*, **39** [10], 141–43 (1931).—Tables are given showing the factors for calculating (1) the Seger formula from the glaze batch composition, (2) the frit composition from the raw materials, (3) the Seger formula from the chemical composition, and (4) the total molecular weight of the fritted glaze from the Seger formula. H.I.

## BOOKS AND BULLETIN

**Chemical Analysis of Iron and Steel.** G. E. F. LUNDELL, J. I. HOFFMAN, AND H. A. BRIGHT. xvi + 641 pp. John Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London, 1931. Price 42s. The book describes the apparatus and reagents commonly in use in the analysis of steel, giving a large amount of general information on common operations, special operations, and volumetric analysis. Methods for the determination of the constituents of irons and steels, gases, oxide inclusions, ferro alloys, ores, limestones, fluorspar, refractories, slag, sands, coal, and coke are given in detail. Illustrated. (*J.I.S.I.*)

**Conversion Equivalents in International Trade.** S. NAFT. Commercial Museum, Philadelphia, Pa. 357 pp., tables. Price $5.00. *Mining & Met.*, **13** [305], 255 (1932).—This is an unusually comprehensive collection of weights and measures, factors, and tables for converting the units of all countries, with special attention to compound conversions and special measures used in engineering, commerce, and various industries. E.J.V.

**Hydrogen Ions: Their Determination and Importance in Pure and Industrial Chemistry.** H. T. S. BRITTON. Monographs on Applied Chemistry. Vol. III. Edited by E. H. Tripp. 2nd ed., revised and enlarged. xvi + 589 pp. Chapman and Hall, London, 1932. Reviewed in *Chem. & Ind.*, **51** [15], 325 (1932). G.R.S.

**Chemical Dictionary: German-English-French.** (Chemisches Fachworterbuch: Deutsch-Englisch-Franzosisch.) Compiled by A. W. MAYER. Vol. II. 943 pp. O. Spamer, Leipzig, 1931. Reviewed in *Chem. & Ind.*, **51** [14], 303 (1932). G.R.S.

**Foundations and Methods of Chemical Analysis by the Emission Spectrum.** WALTER GERLACH AND EUGEN SCHWEITZER. Adam. Hilger, London. Price 12s 6d. Reviewed in *Metallurgia*, **5** [29], 176 (1932).—This work embraces a comprehensive treatment of quantitative spectrographic analysis from its origin. The technique of analysis, using both solid electrodes and solutions, and many useful methods of procedure are described and fully illustrated. Many features are included which increase the usefulness of the book, *viz.*, methods of selecting homologous line pairs, increasing the selectivity in certain cases, where without special means the spectrum lines would

fail to appear, distinguishing between external impurities and those which are the actual content of the sample, methods of quantitative analysis are fully discussed, and it is shown that the method of comparison of spectra is capable of great precision in the determination of small quantities of impurities. See also *Ceram. Abs.*, **10** [6], 459 (1931). M.V.K.

**Use of micropyrometer for high-temperature melting-point investigations.** G. R. FITTERER AND M. B. ROYER. Bur. Mines *Rept. of Invest.*, No. 3151. 17 pp. (Free.) The original micropyrometer method required that the operator determine the melting temperature and detect the "signs of fusion" simultaneously. The present method requires only that the operator detect the "signs of fusion" since the temperature is automatically recorded. R.A.H.

PATENTS

**Separating zirconium, titanium, and hafnium.** M. N. RICH (Westinghouse Lamp Co.). U. S. 1,856,264, May 3, 1932. The method comprises forming substantially pure admixed double alkali metal sulphate compounds of these elements, and separating these compounds according to their relative solubilities in sulphuric acid solutions.

**Production of titanates.** R. H. MONK AND L. FIRING. U. S. 1,856,351, May 3, 1932. A process for the production of a barium titanate from crystalline titanium hydrate which comprises mixing with vigorous stirring barium chloride with the crystalline hydrate to disperse the same, mixing with the dispersed hydrate barium carbonate to coagulate the same, and calcining the coagulated precipitate at a temperature of substantially 840°C to produce a porous mass of barium titanate without colloidal or crystalline characteristics.

**Titanium pigments.** C. A. KLEIN AND R. S. BROWN. U. S. 1,856,565, and 1,856,566, May 3, 1932.

**Production of iron oxide pigments.** JULIUS LAUX (I. G. Farbenindustrie Akt.-Ges.). U. S. 1,857,557, May 10, 1932.

**Treating silica-bearing materials.** T. O. MCADOO (International Silica Corp.). U. S. 1,858,100, May 10, 1932. The process of removing silica from silica-bearing compounds which consists in digesting the silica-bearing compounds in an acid bath, subjecting the digested material to 44 lb. of steam pressure, and removing the silica.

**Purifying ceramic materials.** VEREINIGTE STAHLWERKE A.-G. Brit. 349,033, March 15, 1929. Raw materials (other than sand or other highly siliceous materials) are freed from Fe by treatment first with reducing gases and then with Cl at a temperature of redness to form and volatilize Fe as chloride. (*C.A.*)

**Chrome pigments.** J. Y. JOHNSON (I. G. Farbenindustrie Akt.-Ges.). Brit. 369,916, April 13, 1932.

**Composite titanium pigments.** TITANIUM PIGMENT CO., INC. Brit. 370,088, April 13, 1932.

**Silicates.** SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE SAINT-GOBAIN, CHAUNY, ET CIREY. Fr. 714,357, July 21, 1930. $Na_2SiO_3$ is made in a continuous manner by flowing the $Na_2SiO_3$ into a thin sheet as it leaves the furnace and breaking up the sheet as it solidifies. See also *Ceram. Abs.*, **11** [2], 141 (1932). (*C.A.*)

**Treating titanium ores.** TITAN CO. A/S (Pedor Farup, inventor). Brit. 275,579, Aug. 3, 1926; Ger. 541,486, May 24, 1927. (*C.A.*)

## General

**What the economic depression has done for me.** EDITORIAL. *Bull. Amer. Ceram. Soc.*, **11** [6], 145–48 (1932).

**Materials and Equipment Division to aid American Ceramic Society.** V. V. KELSEY. *Amer. Glass Rev.*, **51** [32], 12 (1932). E.P.R.

**Slag insulation.** EAGLE-PICHER LEAD CO. *Chem. Met. Eng.*, **39** [3], 166 (1932).—Lead blast-furnace slag, formerly a waste product, is now being converted into an insulating wool which weighs 6 lb./cu. ft. G.R.S.

**Dangers of over-mechanization.** ANON. *Brit. Clayworker*, **40** [479], 440 (1932).—It is in the medium-sized and smaller works that over-mechanization so soon becomes a serious menace which must be avoided at all costs. R.A.H.

**Guiana. Porcelain and earthenware in the world market.** H. E. HULDSCHINSKY. *Keram. Rund.*, **39**, 100 (1931). H.I.

**Mexico. Porcelain and white ware in the world market.** H. E. HULDSCHINSKY. *Keram. Rund.*, **39** [11], 161–64 (1931). H.I.

**Guatemala, Salvador, Honduras. Porcelain and white ware in the world market.** H. E. HULDSCHINSKY. *Keram. Rund.*, **39** [13], 190–92 (1931). H.I.

**Nicaragua, Costa Rica, Panama. Porcelain and earthenware in the world market.** H. E. HULDSCHINSKY. *Keram. Rund.*, **39** [16], 236–39 (1931). H.I.

**German fine ceramics industry and the foreign trade situation in 1930 and at the beginning of 1931.** H. E. HULDSCHINSKY. *Keram. Rund.*, **39**, 113–16 (1931). H.I.

**Meeting of the German Brickmakers Assn. at the Leipzig Fair.** ANON. *Tonind.-Ztg.*, **56** [25], 349–50 (1932).—The papers read dealt with the economical problems in connection with a smaller output caused by the depression. See also *Ceram. Abs.*, **10** [12], 868 (1931). W.M.C.

**Three-day convention for brickmakers.** ANON. *Tonind.-Ztg.*, **56** [26–27], 359–61 (1932).—During this meeting, the Tonindustrielaboratorium, Berlin, Germany, as well as several plants in or near Berlin were visited. See also *Ceram. Abs.*, **11** [6], 395 (1932). W.M.C.

**Death of Mrs. Bellamy Storer.** ANON. *Bull. Amer. Ceram. Soc.*, **11** [6], 157–59 (1932).

BOOK

**Flotation.** A. M. GAUDIN. McGraw-Hill Book Co., New York City. 552 pp. Price $6. Reviewed in *Chem. Met. Eng.*, **39** [3], 157 (1932). G.R.S.

PATENTS

**Nonweathering glazed aggregate.** S. F. WALTON (Patent and Licensing Corp.). U. S. 1,855,210, April 26, 1932.

**Nonweathering pigment.** S. F. WALTON (Patent and Licensing Corp.). U. S. 1,855,211, April 26, 1932.

**Ceramic masses.** C. E. EVERY-CLAYTON. Brit. 370,477, April 20, 1932.

**Decomposition of clay.** I. G. FARBENINDUSTRIE AKT.-GES. (Oskar Jonas, Kurt Weger, and Gotthard Trebitz, inventors). Ger. 538,615, Sept. 30, 1926. Clay is heated to glowing, cooled, and loaded into a container in which the clay is subjected to acid circulating at a rate adjusted to cause the reaction to keep the temperature of the mass just above the boiling point of the acid. In the example the clay is treated with acid so that the temperature is between 105 and 120°. (*C.A.*)

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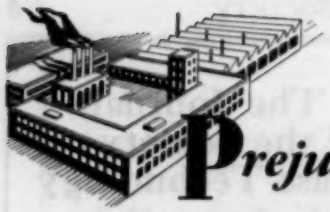

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**A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research**

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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**Vol. 11** **July, 1932** **No. 7**


# EDITORIALS

## LET US DO MORE FUNDAMENTAL THINKING

Empirical thinking is necessary. When making plant application of fundamental facts and theoretical concepts there are so many factors involved that the "cut and try" method is the only feasible procedure. There is no intent to minimize the importance of and practicability of empirical thinking. This plea is not for less systematic empirical ideas, but for more fundamental thinking. To be specific, four examples from the many that readily come to mind will be cited.

**Crazing** To Hermann Seger is credited the theory that glaze crazing is caused primarily by differences in coefficient of expansion and contraction of the glaze and body. As a matter of fact, while Seger recognized that the wholly glassy portion of the glaze would differ from the body in expansion and contraction, yet he gave greater emphasis to the difference in volume changes on cooling and heating which result in stress strains.[1]

H. F. Staley,[2] by fundamental thinking, concluded that cooling strains rather than differences in coefficient of expansion and contraction caused crazing.

[1] This was discussed at length in the *Trans. Amer. Ceram. Soc.*, **13**, 187–90 (1911).
[2] H. F. Staley, *ibid.*, **12**, 322 (1910).

A. V. Henry[3] made refraction stress-strain studies of several glazed specimens and showed his observations graphically. Fundamentally sound as were his studies, his evidence did not warrant his conclusion that stress strains caused by differences in coefficient of expansion were the greater causes of crazings.

The fundamental studies of stress strains in glasses by Preston and several others should make it plain that if there are stresses in the comparatively homogeneous structure of glassware sufficient to cause shattering there would be similar but more plentiful and more effective shattering strain in the extremely unhomogeneous structure which ranges from the pure glass of the glaze surface to the partially fused mineral structure of the body of the clayware.

Differences in coefficient of expansion between the glaze and body are not the prime cause for crazing.

**Engobes** The fallacious reasoning that to make a perfect "fit" the engobe must have the same drying shrinkage and the same coefficient of expansion as those of the body of the ware has confused many empirical thinkers. This applies not alone to engobed ware but also to such bonded ware as refractories and grinding wheels.

The engobe and the bond must possess a coherence, an adhesion, and to some extent a fluxing bonding relation with the "body" which it covers. Their volumes change in the kiln cooling cycle and are of vastly more importance than shrinkage in the green and coefficient of expansion in the fired state.

Volume changes, their rate, and their irregularity are of greater importance in glasses, glazes, enamels, and clayware than is generally suspected.

**Combustion** Kiln firing, notwithstanding the large amount of fundamental studies published, is still on the premix rather than on the contact combustion basis. If the extremely simple principles of diffusion combustion were put into practice, more even heat distribution and less fuel used would result. Kilns generally are fired on the premix basis and due only to accidental and out-of-condition features of the kiln is there sufficient diffusion combustion to secure passable heat distribution.

Kiln design and kiln firing are most generally done without much fundamental knowledge of the sort of combustion required.

There need be no kiln smoke nuisance. A slight alteration of the kiln and of the coal-firing schedule will heat the bottoms and centers along with the top without causing smoke to belch from the stack, a change from the premix to the diffusion and contact combustion principles.

**Colloids** It is surprising to fundamental science thinkers that ceramists can not limit their ideas of the clay colloids responsible for plasticity to small particles. All of the phenomena of thinning and thickening of clay slip by addition of salts are due to electrolytic reactions repelling and collecting these small clay particles.

The effective colloids in clays are not jellies that swell on taking up water and form a slippery medium for the water-insoluble clay products.

Very simple and frequently reported experiments show that clay par-

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[3] A. V. Henry, *Jour. Amer. Ceram. Soc.*, 8 [2], 117 (1925).

ticles, for reasons unknown, are endowed by nature with high adsorptive abilities.

It needs no deep fundamental thinking to realize that the ratio of surface to mass increases with decrease in particle size and that the small particles expose the largest effective adsorptive area and in turn the most electrolytic salt reactions.

Why "mush" our minds with colloid facts and concepts unrelated to clay?

It has led to a lot of wasteful experimenting and kept confused our ideas of what really are the simple physical causes for plasticity and for slip control.

Let us get down to fundamentals. Clearer thinking on the basic "whys" will simplify and make more effective the empirical plant proving and plant control.

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## READERS' DIGEST

These depression conditions have limited our news and magazine reading to "digests." One evening we read three articles as they were published originally. The next week we read three "digests" of these same articles. Our curiosity caused us to contrast the original and the "digest" of these three articles to see where the digest might have left out important thoughts and citations. The digests accurately and fully presented the thoughts of the authors' facts and conclusions. The result was a query as to why the editors of these articles in the original had not saved printing costs and their reader's time by "digesting" these articles in the first place.

Your editor has been trying to make such a condensation of articles published in the *Journal* for its writers and readers. It is our aim to print only the material that is necessary to convey the findings and conclusions of the authors.

Furthermore, we aim to conserve space. The illustrations are intended to be no larger than necessary to disclose their intended information clearly. This conservation of space results in making available room for more printed information.

As for valuable digests of our ceramic literature, our *Abstracts* speak for themselves. So successful are we in gathering the published information of interest to ceramists from all parts of the world that we are continually forced to increase our "digesting" and our economizing on page space in order to be able to present this material.

We are doing our best with the money available and the best we do is worth many times the cost.

The index in the December issues is another digest, the value of which can be appreciated only by those who use it.

# PAPERS AND DISCUSSIONS

## SYMPOSIUM: CONTROL TESTING IN CLAY FIREBRICK MANUFACTURE*

### I. Desirability and Necessity of Control Tests

By Fred A. Harvey

ABSTRACT

This Symposium is composed of a series of papers on the subject of control testing in clay firebrick manufacture. The subjects discussed are as follows: (1) desirability and necessity of control tests; (2) proper size and methods of sampling; (3) mine sampling and selection of clays; (4) laboratory testing of clays; (5) control tests on grinding and sieving; (6) control tests for moisture in fire clay and fireclay bodies; (7) use of the ammeter to control moisture at the pug mill; (8) green brick control at the press; (9) reproduction of service conditions in the laboratory; (10) control of firing operations in the manufacture of clay fire brick; and (11) control testing of fired brick from the viewpoint of the American Society for Testing Materials Methods.

Manufacturers of refractories have frequently been told in recent years that they have lagged far behind other industries in development and in the production of a uniform product. Consideration, however, is being given by the manufacturers to ways and means by which greater uniformity may be attained. In the selection of suitable methods and procedures the costs involved in their use are of vital importance. One of the simplest tests which can be made to determine refractory quality of a brick batch is the P.C.E. test. Assuming that such determinations could be made for $1.80, there would be a charge of $7.20 per thousand if each four pans of batch required to make 1000 brick are tested as was recently suggested. With first quality fireclay brick selling at from $35 to $38 per thousand, such charges are obviously out of the question. Again, records indicate that routine screen tests including calculations and reports can be made for about 80 cents each. Four pans at 80 cents would be $3.20 per thousand, still too high for consideration.

How much is it necessary to spend in efforts to produce a more uniform product? In answering this question one fundamental principle must be established, *i.e.*, the only control testing which can be done without increasing the cost to the consumer is testing which pays its own way. The control tests can do this in a number of ways.

(1) If by control testing breakage can be reduced by 1%, approximately 35 cents per thousand based on present prices has been saved.

(2) If a manufacturer forges a little ahead of his competitors in uniformity of product he stands a better chance of holding his customers and of getting new business than he did before he made the advance.

(3) The costs at every stage in the mining of the clays and process of manufacture offer possibilities of slight reductions to be applied on the

* Editor's Note: It has been necessary to effect a material condensation of the papers presented at the Control Test Symposium. The Editorial Committee has endeavored to present the essential parts of each paper, but it should be recognized that style, and to some extent, the argument, used by each author has been altered in the paper as presented here. This Symposium was part of the program of the Refractories Division at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932.

testing bill. For example, it might happen that selection in the mines caused the rejection of clay which is suitable for use in some other product being made. Of course, the reverse may equally prove to be the case and clay being shipped may prove to be of a quality which should be rejected.

(4) Firing costs as well as breakage should be slightly lower with a uniformly fired product than with one which is up and down.

(5) The advertising value of close control should not be overlooked.

(6) Complaints are expensive and should be reduced by closer control.

(7) Another intangible asset is increased confidence of the sales force as control is improved. Unfortunately there can be no accurate measure of the direct bearing of control tests on any of the sources of savings indicated.

It may be worth while to do a little cost estimating. A simple control laboratory can be built and equipped for about $10,000. Experience shows that such a laboratory can be operated at about $400 per month. On a plant producing 60,000 nine-inch equivalents per day, or 1,560,000 per month, this amounts to a little under 26 cents per thousand, assuming capacity output. On account of fluctuations in capacity a small independent plant can frequently operate more economically by utilizing the services of the Refractories Fellowship at Mellon Institute.

The difficulties to be met in a control-test schedule must not be overlooked or minimized. The problem simply stated is for one ceramic engineer to keep a close check and maintain a definite standard on 60,000 individual pieces every day. The problem would appear hopeless were it not for the possibilities presented in educating the men carrying out the actual operations. The mine foreman and through him the miners themselves, no matter how much they already know about clays, will learn more by seeing the results of various tests. The pan man learns the proper grind and moisture by the "feel" of the batch, and so on all along the line.

A general method should be to take the old procedure in which the operator or foreman is the final judge and build on his experience by giving him an accurate measure of the things he does each day. In doing this a permanent record for reference is set up.

The longer a record of a given control test is maintained, providing it was worth anything in the first place, the more valuable it becomes. Without such records changes in procedure may occur so gradually as to be imperceptible to those in daily contact with the process.

It must also be remembered that patience is a prime requisite for those in authority. A concrete example may be cited. A plant had been operating for a number of years without pyrometers on the kilns. A system was installed. It was recognized that information showing the best firing schedule was not available. Records of temperature were therefore kept for one year before making any effort to change existing conditions. At the end of this period all of the data were studied, kiln temperatures, breakage, coal consumption, as well as other factors involved, and a firing schedule was established. It took several more months to approximate the schedule, but when it was finally established the average breakage was lowered and underfired brick were practically eliminated.

An interesting address by Lawrence V. Redman of the Bakelite Corpora-

tion, was recently published.[1] Among several valuable suggestions, Mr. Redman says:

> Average experience suggests as a fair expectancy, from the start to the full liquidation of the investment, a period of seven or eight years. If this time means too long to the average investor, we would remind him that certain engineering projects call for an equal exercise of patience.

Control testing might be called the "little brother of research," and like research it is apt to take months of effort before the tangible evidence of its value becomes apparent.

HARBISON-WALKER REFRACTORIES COMPANY
PITTSBURGH, PA.

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## II. Proper Size and Methods of Sampling

BY A. E. R. WESTMAN

Four contributions of recent years show that gratifying progress has been made toward solving difficulties involved in sampling. These concern (1) sampling procedure, (2) significance of an observed average, (3) sample size, and (4) agreement of duplicates.

### (1) Sampling Procedure

Those who deal in refractory materials and are faced with the problem of sampling deliveries under contract over periods of several months should be interested in a paper by Grumell and Dunningham.[2] After a thorough experimental and theoretical investigation of the sampling of coal their conclusions were as follows:

> (1) A 50-pound sample of class A coal is as accurate as a 465-pound sample of mixed cargo.
> (2) A 50-pound sample consisting of 10 increments of 5 pounds is as accurate as a 500-pound sample was considered to be by the "size-weight-ratio" theory.
> (3) Many small increments are better than a few large ones.
> (4) The variability of a coal can be estimated from its approximate ash content.

### (2) Significance of an Observed Average

An important question which arises frequently is the following: Given the average value of a sample what may be said about the true average value, *i.e.*, the average value of the "population" from which the sample was drawn? If the population is normal and its standard deviation, *i.e.*, its variability, is known from past experience, an interesting answer to the above question is given by Egon Pearson.[3] (See Fig. 1.) Here two normal frequency distributions of averages of samples of the size under consideration are shown having averages at $a_1$ and $a_2$ and overlapping at the value of the observed average. The chance of getting values as rare or rarer than the observed average from either of these populations is the same,

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[1] L. V. Redman, "Research as a Fixed Charge," *Ind. Eng. Chem.* (1932).

[2] Brit. Eng. Stand. Assn., No. 403 (1930).

[3] For details regarding this and other interesting applications see J. F. Tocher, "What Is Probable Error?" Institute of Chemistry of Great Britain and Ireland, April (1931); for a discussion of the fundamental theory, consult J. Neyman and E. S. Pearson, "On the Use and Interpretation of Certain Test Criteria for Purposes of Statistical Inference," *Biometrika*, **20A**, 175–240 (1928).

*i.e.*, a chance of one in twenty. If $a_1$ and $a_2$ are placed farther apart the chance of getting the observed average is less than one in twenty. Consequently, there is justification for concluding that the true average value lies between $a_1$ and $a_2$.

**(3) Sample Size** Samples usually are taken in order to make an estimate of the average and standard deviation of a "population." The influence of sample size on the accuracy of this estimate is not generally appreciated. Figure 2 shows experimental results obtained by sampling from a normal population.[4] The average of the population is shown at the center and the averages calculated from various sizes of samples are shown by the dots. It is interesting to note how closely they group around the true average when large samples are taken.

Figure 3 shows what happens when sampling to find the standard deviation. The true value is shown by the line at the center and is equal to ten. As with the observed averages, the observed standard deviations cluster around the true value as the sample size is increased, but note

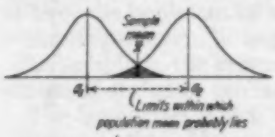


FIG. 1.—Diagram showing that it is improbable that the true mean is less than $a_1$ or greater than $a_2$. The odds are 19 to 1 against the mean being less than $a_1$ or greater than $a_2$.

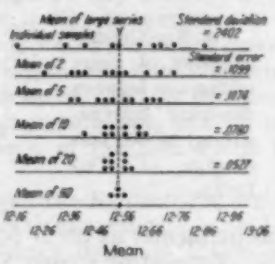


FIG. 2.

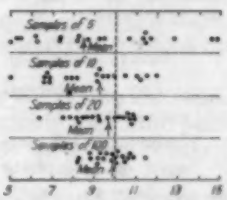


FIG. 3.—Distribution deviations in repeated samples. Population standard deviation = 10.

that with small samples the mean of the observed values is lower than the true value. In other words, there is a tendency to underestimate the standard deviation when small samples are used. This is an important consideration and the reasons for it will be discussed later.

**(4) Agreement of Duplicates** If a large number of samples of two are drawn at random from a normal population, the first of each pair should not in the long run be larger or smaller than the second, and therefore, the mean value of the difference first-minus-second should be zero. In other words (no matter how variable is the population), the most probable value of the difference between duplicates is zero. Since the population is normal, the differences first-minus-second will be distributed normally. An example, given by Tocher,[4] is shown in Fig. 4.

Now, the standard deviation of a sample of two is equal to $^1/_2$ the *absolute* value of their difference, so if all the differences are made positive in Fig. 4, the distribution of observed standard deviations may be obtained. This is equivalent to taking the negative half of the normal curve in Fig. 4 and adding it to the positive half producing the positive half of a normal curve of twice the area. Figure 5 shows why small samples give low estimates of the true standard deviation. Zero is the most probable observed

[4] J. F. Tocher, see footnote 3.

value. Observed values on large samples (approximately 25 or more) are distributed normally about the true standard deviation; for sample sizes between samples of two and large samples, curves intermediate in shape between that of Fig. 5 and a normal curve are obtained.

From what has been said, agreement between one pair of duplicate determinations (*i.e.*, a small observed standard deviation in a sample of two) does not in itself warrant the conclusion that a method is accurate. This is illustrated in Fig. 6, in which $s$ is an observed standard deviation in a sample of two, $A$ is the distribution of such values to be expected from a normal population having a standard deviation $\sigma_1$, and $B$ is a similar distribution for a standard deviation, $\sigma_2$. Although $\sigma_2$ is more than thirty times $\sigma_1$ the $B$ population would give values

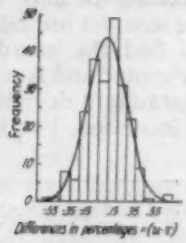


FIG. 4.—Normal curve fitted to differences in percentages of phosphate $= (u - v)$.

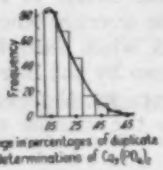


FIG. 5.—The distribution of range (difference between duplicate determination) in the percentage of $Ca_3(PO_4)_2$.

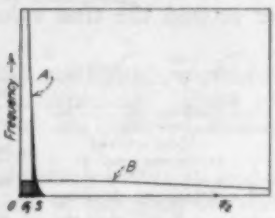


FIG. 6.

as low or lower than $S$ as frequently as the $A$ population would give values as high or higher than $S$. Estimating $\sigma$ from $S$ alone[5] is therefore an uncertain process.

**(5) Conclusions** Enough has been said to show how uncertain are estimates of standard deviations based on small samples. Unless a restriction is made to large samples, therefore, it is essential that the standard deviations of the populations to be dealt with should be known in advance. Such knowledge can be obtained best from data obtained over a considerable period and reported in the correct form. Attention is drawn to a test manual issued by A.S.T.M. Committee C8 in which this correct form is described.[6]

ONTARIO RESEARCH FOUNDATION
TORONTO, ONTARIO

## III. Mine Sampling and Selection of Clays

BY G. A. JOHNSON

The sampling and selection of clays from a fireclay mine should be predicated on knowledge and experience with quite a varied list of factors. The points at which samples should be taken and the frequency would depend almost solely on local factors such as (1) quantity of clay stripped ahead, (2) face worked and clay demand (if a strip mine is being worked),

[5] There are frequently other considerations that make values as high as $\sigma_2$ unlikely or impossible. Figure 6 is not amenable exactly to the same reasoning as was used with Fig. 1.

[6] J. S. McDowell and A. E. R. Westman, "A Manual for the Interpretation of Refractory Test Data," *Proc. A.S.T.M.*, **30** [1], 478–504 (1930).

and (3) the plan of mining, number of rooms, and clay demand (if an underground mine is being worked).

The distance between samples and the frequency in time of sampling depend also on local conditions. Under ordinary circumstances when working a fairly long face (*e.g.*, 300 feet) samples may be taken every 30 feet. If any variations then show up or there are visible impurities between sampling points, additional samples may be taken between these points. The splitting vertically of the sample will depend on the seams of clay in the bed and the variations of quality of these seams, as well as on the grades of products being manufactured and the method of mining. Under these conditions, the actual mining can be made to follow the sampling. By working out the clay over a reasonable length of face, it can be sampled ahead satisfactorily without drilling, especially in strip mining. The time-interval between periods of sampling varies entirely with the bank being worked. With ordinary clay demand from the shop and presupposing that the quality has been running uniformly for a month or two, the bank can be sampled every ten days or two weeks. If the bank is running uneven, however, it may be necessary to sample every few days.

In sampling, the exact location of the sample taken should be marked by means of stakes or reference points of some character.

The impurities which can be checked by the senses are (1) excess sand, (2) any nodules of lime or iron minerals, and (3) in some cases lime salts which crystallize out in parts of the face which have not been worked continuously.

Samples for checking impurities by chemical methods should be more in the nature of "grab" samples than average.

For general control purposes (such as P.C.E. samples) the sampling should be done with great care so as to include a representative portion of all the material present.

Since the selection of clays from a mine is based primarily on the samples taken and the tests made on these samples, it is evident that the sampling must be done carefully and thoroughly or the results will not be representative of the actual material in the mine.

Robinson Clay Products Company
Dover, Ohio

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## IV. Laboratory Testing of Clays

By R. F. Ferguson

Tests designed primarily for the purpose of controlling the clays used in the manufacture of clay refractories are outlined. The procedure is not complete, but includes the tests which will give the greatest return for the money spent.

**(1) P.C.E. Tests** Pyrometric cone equivalent tests should be made on all clays used. The routine composite samples of the clays or green mixes should be supplemented by periodic face samples from the mines. These face samples should be taken on all working faces at regular intervals, preferably above ground, rather than by the miners. The frequency of sampling will be determined by the nature of the clay and the rate of advance. In old mines it is advantageous to

sample the main heading more frequently than the side headings and rooms.

**(2) Green Breaking Strength Test** On plastic clays a simple and useful test is the green breaking strength test. As the function of the plastic clay is primarily to bond the brick until it is fired and to give it the necessary fired strength, it is important to control this bonding ability. The test is inexpensive and can be carried out with simple apparatus. This test should also be made at periodic intervals, a composite sample being used for control, supplemented, at less frequent intervals, by face samples such as described for the P.C.E. test.

**(3) High-Temperature Reheat Test** A routine test on the raw material in its ultimate form can be made by giving the finished brick a high-temperature reheat test, *e.g.*, 1500°C or 1600°C (2700°F or 2900°F), depending on the type of product. The sample can be taken from the kiln or cars before the brick are cool enough to load and the test completed before the brick are shipped. Low-melting impurities will sometimes be evident that might have escaped detection in the P.C.E. test. If the reheat is combined with a porosity determination before and after the test, it will be still more valuable because any incipient fusion will result in a lowering of the open pore space.

**(4) Complete Firing Behavior** A manufacturer should also have a record of the complete firing behavior of each type of clay used and of each mix employed. This information can be obtained by making draw trials which will give the shrinkage, porosity, color, closed pore space (as indicated by the specific gravity), and crushing strength for a range of temperatures extending from below maturity up to incipient fusion. With such data available, a much more intelligent use can be made of the raw materials by combining types of clays to produce brick of desired characteristics.

**(5) Periodic Tests** Periodic tests should be conducted on the finished brick, annually, semi-annually, or quarterly. These tests will reveal long-time trends in the clay quality. They should include the spalling and load tests, and the determination of the modulus of rupture. If they are made regularly, a standard performance will be established for each brand.

**(6) Chemical Analysis** Chemical analysis finds its greatest usefulness in "trouble-shooting," but is also of high utility when a treacherous clay is being mined. If patches of clay high in iron or alkalis are frequently encountered, a chemical determination of these constituents will be a more accurate guide than physical tests alone. Then too, in making a very high-grade product, the chemical analysis will show smaller variations than can be revealed by the P.C.E. Furthermore, when the physical tests indicate the presence of an undesirable impurity, or a decline in quality, chemical analysis is invaluable as a means of identifying and locating the offending constituent.

These tests must not be considered as all of those which might be made with profit, but are rather the minimum number needed for the control of raw materials in making clay brick.

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PITTSBURGH, PA.

## V. Control Tests on Grinding and Sieving

By R. S. Bradley and R. B. Gilmore

Control of the relative size and proportion of sizes of the raw and calcined clays used is of considerable importance in the manufacture of fireclay brick. Variations in grain size affect the uniformity and most of the physical properties. This holds true for fire brick manufactured by the dry-press, stiff-mud, or hand-made processes, and of coarse, medium, or fine texture. Control is generally considered of more importance in the manufacture of dry-press and hand-made brick of coarse texture and particularly those containing large percentages of raw or calcined flint clay.

A positive way to maintain a uniform grind is by making occasional sieve analyses on the individual materials and on the mix as a whole and by comparing the sieve analysis with a standard analysis to determine whether the size of the material tested is within the allowable limits. It is more convenient to establish maximum and minimum limits for the percentage allowable on one of the coarser sieves and through one of the finer sieves. This method is satisfactory inasmuch as a more or less definite ratio exists between the percentages retained on the intermediate sieves.

Control is more easily maintained where the plant is equipped to do multiple screening or where the individual materials are double-screened through a coarse screen and over a fine screen.

Control of the grain size is of importance from the production angle because of the effect it has upon the shrinkage and bonding strength of the fireclay brick.

It is difficult to predict what effect variations in grain size will have in individual cases because it depends to a large extent upon the proportion of raw and calcined clays used in the mix, whether the raw clays are plastic or flint, and the physical properties of clays used. As a rule, increasing the fineness of plastic clays tends to increase the manufacturing shrinkage and the modulus of rupture strength of the green and fired ware. Increasing the coarseness of the calcined clays tends to decrease the shrinkage and in some cases decreases the bond. This latter is particularly true where calcined flint is used.

The physical properties of brick (in service) depend chiefly on the physical properties and chemical composition of the clays, as well as percentage of raw and calcined clays used and the method of manufacturing and degree of firing. Control of grain size, however, is also of importance in developing and maintaining such physical properties as spalling resistance, permanent volume, slag resistance, and heat-resisting property.

Control is most important in manufacturing brick designed to withstand spalling. As a rule, brick of coarse texture are most resistant to spalling, and the proportioning of coarse, medium, and fine particles is important.

It is possible to alter the permanent volume properties of some fireclay brick and to eliminate service shrinkage by variations in the relative size and proportion of sizes of the clays used. This is particularly true where a large percentage of coarse calcined flint clay is used. Coarse calcined flint apparently has the property of causing an after-expansion.

The use of fine grinding is not entirely necessary to produce brick of sufficient density to resist slag action. A coarse-textured brick of very low porosity may be produced when the size of the grains is properly

proportioned to reduce the percentage of voids to a minimum. It is possible to accomplish this by decreasing the percentage of medium-size grains.

The heat-resisting property of brick of the same mix, but of different texture, is usually higher for the brick with the coarsest texture. This is particularly true where the coarse particles form the body of the brick and only a minimum percentage of fines fill the voids. A questionnaire was sent to a number of refractories manufacturers to determine the extent to which control tests on grinding and sieving are now being used by the manufacturers of fireclay brick, their importance, and the uniformity of procedure for making sieve analyses. The following results were compiled from the answers:

(1) Control tests on grinding and sieving are considered important and are used to some extent by most manufacturers.
(2) They are important in the manufacture of brick by the dry-press, stiff-mud, and hand-made processes.
(3) They are important on brick of coarse texture and particularly those designed to resist spalling.
(4) The size of the plant screens is designated by the size of the openings and by the number of meshes per inch. Most plants designate the screen size by the size of openings.
(5) Most plants control the size of product by changing only the size of the screen. Some change the size of the screen plates in the dry pan and vary the weight of the mullers.
(6) There is little uniformity of procedure for making sieve analyses.

The frequency at which samples are taken varies from hourly to weekly. The majority of plants report that samples are taken daily.

The size of the sample obtained varies from 5 to 25 pounds, with an average of about 15 pounds.

Most companies report that the sample is obtained by "grabbing" from conveyer or chute.

About one-half of the companies use a sample splitter for quartering the sample. The remainder use the hand method of quartering.

The size of the sample tested varies from 100 to 1000 grams; the average is a 200-gram sample.

All but one of the companies use Tyler sieves which are selected for the following reasons: (*a*) considered more standard, (*b*) easier to obtain, and (*c*) better curve obtained for plotting results. The range of sieves used varies from 3- to 200-mesh.

The allowable limits in variation from standard analyses given were from 1 to 10%; most of the companies did not report any limits.

A technical bulletin of the American Refractories Institute[7] points out the importance of careful control of the degree of grinding and proportioning particle sizes in order to assure uniformity in the properties of brick and also close adherence to size.

The information obtained from the work conducted by Mr. Ferguson and the questionnaire emphasizes the necessity and importance of establishing a standard procedure for making sieve analyses for refractory materials.

NOTE: The late R. B. Gilmore, co-author of this paper, was affiliated with the North American Refractories Company at the time of his death.

A. P. GREEN FIRE BRICK COMPANY
MEXICO, MO.

[7] R. F. Ferguson, "Sieve Analysis for Refractory Materials," Amer. Refrac. Inst., *Bull.*, No. 31 (1931).

## VI. Control Tests for Moisture in Fire Clay and Fireclay Bodies

By Stephen M. Swain

Water is added to fireclay bodies for the plasticity that it develops in the clay. For a given clay or body the plasticity is proportional to the amount of water present. In order to keep the plasticity of various uniformly prepared batches constant the moisture content must be kept uniform.

The different batches or portions of a batch, however, vary in their properties somewhat so that the plasticity is not always proportional to the moisture content. These variations may be in the ingredients themselves, in their relative proportions in the body, in the grading of the various grain sizes, or in the kinds and amounts of soluble materials in the clays or water.

It seems probable that the correct method of adding water to clay bodies which vary within reasonable limits is to bring the batches to a uniform plasticity. Such batches should also show similar shrinkages and similar textures in the finished product.

If these variations in the relation of plasticity to moisture content are small, control of the per cent water will control the plasticity to within close limits. If the variations are large, control by this method will be proportionately inexact.

From the time the clay is mined until it is fired it is continuously changing in moisture content. These changes affect the grinding, the screening, and the proportioning of the ingredients of the body, especially if they are measured by volume.

Control tests for determining the per cent moisture in fire clays and bodies may be divided into three classes according to the general method used.

(1) Measurement of the water itself by weight or volume.
(2) Measurement of specific properties of the clay or body influenced by variations in the amount of water present.
(3) Measurement of specific properties of a substance added to the moist clay or body and mixed thoroughly with it, these properties being changed by variations in the amount of water present.

### (1) Measurement of Loss of Weight on Drying

The most common method of the first group is the determination of the water by loss on drying at 105 to 110°C (221 to 230°F).

For control tests the sample may be dried only to a given state under carefully controlled conditions and a definite number added to give a final estimate of the moisture content.

The method is applicable to all types of clay bodies. The main disadvantage of the test is the length of time required for a determination.

### (2) Measurement of Water Distilled

A second method of determining moisture directly involves distilling the water with another liquid of similar boiling point, the two liquids being mutually insoluble so they may be separated after distillation. The principle and apparatus are similar to that of the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. designation D95–30) with the substitution of a burette instead of a graduated trap as suggested by Navratiel.[8]

[8] Hans Navratiel, "Rapid Method of Determining Moisture Content of Ceramic Materials," *Ber. deut., keram. Ges.*, **12** [2], 90 (1931); *Ceram. Ind.*, **17** [2], 137 (1931).

**(3) "Feel" Test** The first test of the second type is that of working the clay in the hand to judge by the "feel." This is the most common control test used and is really an endeavor to measure the plasticity.

The property, plasticity, however, is difficult to define or measure. No definite values can be determined by this method.

The method will continue in use, however, since it measures a property closely connected with plasticity, is simple to perform, and requires no instruments. The method is applicable to all clays of all the usual moisture contents.

**(4) Tests of Deformation** Many tests have been proposed to replace the "feel" test by a more exact one. Practically all of them have determined the resistance to deformation. Five distinct modifications will be noted here.

**(a) Constant Pressure** S. J. McDowell[9] reported a method in which he applied a load of 8000 grams to a 2-inch test cube for 30 seconds and recorded the deformation to $\pm 1/64$ inch.

**(b) Measurement of Pressure for a Given Deformation** A highly refined method has been reported recently by Rowland and Galloway.[10] A carefully prepared test piece is deformed a given amount at a given rate by means of a motor-driven cam. The maximum pressure transmitted by the clay to the opposite face of the testing machine from which the pressure is applied is recorded automatically on a chart.

**(c) Deformation Measurement over Limited Area by Constant Pressure** To test stiff mud a modified form of Vicat needle is used. The area of the needle "point" must be fairly large, especially in coarse-grained bodies. The needle is placed in contact with the smooth surface of the clay sample and allowed to penetrate the clay for a given time. The depth of penetration is recorded. The area of the needle "point," the weight of the needle, and the time of penetration must be adjusted to suit the body being tested.

**(d) Measurement of Pressure for Given Penetrability by Needle** A needle of suitable area might be substituted for the upper plate of the test apparatus of Rowland and Galloway[10] to test mud too stiff for that instrument. The same arrangement for cutting the specimen could be used.

**(e) Measurement of Depth of Penetration of Ball** This method makes use of gravity as a constant energy source. A ball of brass or other suitable material is dropped from a definite height and the depth of penetration into a clay slab measured. The measurement of the depth of penetration is made best by determining the distance between the top of the ball and the top surface of the clay test slab far enough away from the ridge raised up by the ball to measure the original surface. This distance subtracted from the diameter of the ball gives the depth of penetration. The test is applicable to mud prepared for hand molding or for the auger machine.

**(5) Measurement of Power Required to Mix Mud** The power required to mix clay in a pug mill may be used as an index of the amount of water present or of the plasticity. It is necessary that the machine be driven by an electric motor. A wattmeter (or an ammeter if the voltage remains constant throughout the day) is connected in the motor circuit to measure the power used. The amount of clay passing through the mill must be kept constant. The gears must be kept uniformly lubricated and compensation must be made for changes

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[9] S. J. McDowell, "Notes on a Method for Determination of Workability of Plastic Clays," *Jour. Amer. Ceram. Soc.*, 11 [2], 99 (1928).

[10] D. H. Rowland and H. L. Galloway, "Measuring Stiffness of Clay," *Ceram. Ind.*, 17 [6], 466 (1931).

in temperature of the grease on the gears since these factors affect the power reading also.

**(6) Measurement of Bulk Density** The amount of moisture in relatively dry clay which has been ground and screened can be estimated from the bulk density. By determining the bulk density and per cent moisture of a large number of samples of a given clay or body a table or graph may be prepared from which the per cent moisture may be estimated from a bulk density determination.

The method is applicable only to relatively dry clays, approximately 5% of moisture or less, and to clays which have been screened and are of uniform grain-size composition.

**(7) Measurement of Wet Modulus of Rupture** A measurement of the bond developed by clays and bodies containing small amounts of moisture and suitable for dry pressing may be used to indicate the amount of moisture present. A bar of clay, *e.g.*, 9 by 1 by 1 inch, is prepared by pressing a given amount of clay under a standard pressure. The modulus of rupture is determined immediately on the wet bar. The strength of the bar varies with the bonding power of the body which in turn varies with the amount of moisture present.

**(8) Surface Moisture by Changes in Specific Gravity of Salt Solution** Recently an instrument[11] for determining the surface moisture of granular mineral material has been described. The test method depends on two characteristics of a saturated solution of sodium chloride, (1) that its specific gravity changes but little

TABLE I

| Type of material | Drying | Distillation | Feel | Deformation-constant pressure | Deformation-maximum pressure | Penetration-constant pressure | Penetration-maximum pressure | Ball | Wattmeter | Bulk density | Wet modulus | Salt solution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| "Dry" clay in preparation | *A* | *A* | *A* | | | | | | | *S* | | *A* |
| Soft mud for hand molding | *A* | *A* | *A* | *A* | *A* | *A* | *A* | *A* | *A* | | | *A* |
| Stiff mud for auger machine | *A* | *A* | *A* | *S* | *S* | *A* | *A* | *A* | *A* | | | *A* |
| Clay for dry press | *A* | *A* | *A* | | | | | | | *S* | *A* | *A* |
| Finished brick | *A* | ? | | | | | | | | | *S* | *S* |

*A* = applicable.
*S* = applicable under special conditions.
? = questionable applicability.

over the usual room temperature range, and (2) that such a solution is extremely deliquescent and therefore mixes quickly with any moisture in contact with it.

The fact that this method gives surface moisture may be a distinct advantage in bodies made up of large amounts of flint clay and grog, since it is the moisture on the surface of the clay and grog grains that makes the mass plastic. The amount of moisture in the pores of the grains of flint clay and grog can influence the plasticity only when these pores take up

[11] "A New Means to Determine Surface Moisture," *The Laboratory*, **4** [5], 74 (1931).

water from the surface and thus reduce the amount there. The last action need be considered only when the test is made soon after the water is added and some time will elapse before the clay is formed.

Table I shows the applicability of the various tests to different types of material to be checked.

General Refractories Company
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## VII. Use of the Ammeter to Control Moisture at the Pug Mill

By J. Otis Everhart

Power consumption in clay-plant operation is primarily dependent on two factors, (1) the nature of the process, and (2) the type of material being processed.

In crushing and grinding operations the hardness or toughness of material has more effect on the power consumed than does moisture content. Where clay is processed after grinding by the addition of more moisture the effect on the power required is increasingly noticeable as the restriction to free movement of the clay particles increases.

Apparatus for controlling moisture by indicating power consumption may be installed on stiff-mud machinery with greater success than on equipment related to the dry-press process of manufacture.

It is scarcely to be recommended that a recording wattmeter be installed as a permanent piece of equipment at any stage of manufacture. It is suggested rather that an indicating ammeter be installed where the operator of each machine may watch it and gage the operations according to its behavior. A recording wattmeter for securing a record of continuous operation in any of the various processes is a desirable addition to the equipment of every plant. By its use an analysis of the situation may be made and conditions corrected which might otherwise remain undiscovered. For constant control the indicating ammeter which may be economically installed is to be recommended.

In pugging and extruding operations addition of water to the dry body increases the ease of slippage between individual particles, and between particles and machine parts. Because of this lubricating quality any change in the moisture present becomes immediately noticeable. When the opening through which the clay is forced is restricted as in an auger machine, the result is multiplied over that produced by a pug mill where the end is open. Consequently, if the instrument is to be installed at the pug mill one of a more sensitive nature is required for indicating the change.

Unless conditions exist which make it impossible or inconvenient to install the power-measuring equipment on the auger machine it should by all means be placed there, rather than on the pug mill.

Tests at the Engineering Experiment Station have shown that in auger-machine operation the power consumed is not exactly a straight-line function of moisture content or rate of production, while with the pug mill it is thought that such is the case. This difference arises from the restriction of the die opening.

If a definite ratio is once established for any particular clay it is a

comparatively easy matter to adjust the moisture content within limits of ½% or less by placing an ammeter where the pug-mill operator may watch it.

O. S. U. Engineering Experiment Station
Roseville, Ohio

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## VIII. Green Brick Control at the Press

By L. C. Hewitt

Excluding the influence of factors before pressing, control at the press rests chiefly in mechanical means, *i.e.*, more through proper machinery and careful machine set-up prior to manufacture than through control tests.

**(1) Dry-Press Process**[12] Assuming a change in dies, the proper set-up is most important in the success of the expected run. Liner plates must be checked for wear and renewals made, if necessary. Where multiple dies are used, as for 9-inch brick, the spacing of each in respect to the depth of the charge must be uniform. Such spacing as well as the feed distribution may be checked by running the press and increasing the pressure until "pressure cracks" develop. The failure of such cracks to develop in all of the brick indicates a variance in the die spacing and improper distribution of the feed, *i.e.*, uneven amounts of clay in the die boxes due to wear of the charging stick. If a measure of the brick shows uniform thickness, the variance is due to the feed distribution. With any such variance determined and corrected, the start of the run is made by applying pressure again until pressure cracks occur, then releasing the pressure to the point where a sound structure is produced. Changes in the moisture content, clay structure, or particle size as affecting the pressure transmission or hardness are factors that influence the need for pressure change.

A number of plants have a small indicating scale near the presses for the purpose of checking green brick weights. This serves as a guide for showing up large variations, though it does not indicate the cause. Variance in weight may be due to change in moisture content, grain size as affecting density, or variation in feed or charge.

**(2) Stiff-Mud Process** As in the case of dry-pressed brick, control prior to forming is the main factor in the stiff-mud process. Proper tempering, water content, and condition of the auger govern the quality of the clay bar, which in turn governs the success of the pressing operation. The greatest factor affecting green brick size is cutting the clay bar into uniformly sized dobies for feed to the re-presses. A type of cutter which moves with the clay column by individual power is preferable to one which is motivated by the push of the bar itself. In any case, the mechanism must be closely watched in order to maintain uniformly spaced and taut wires. In some cases devices for shaving or cutting the clay dobies to uniform thickness are used.

In respect to the actual pressing or re-pressing operation, the die set-up is important, but once set it is not materially difficult to maintain. Ex-

[12] Also referred to as semi-dry process (mechanical type).

cessive pressure causes the brick to swell or develop pressure cracks and insufficient pressure does not fill them out. The necessity for liner alterations to overcome variation in size because of die wear becomes evident when the brick show a fringed edge.

LACLEDE-CHRISTY CLAY PRODUCTS COMPANY
ST. LOUIS, MO.

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## IX. The Reproduction of Service Conditions in the Laboratory

BY F. H. NORTON

If the time and expense could be allowed, the most satisfactory test for a refractory would be under the actual conditions of use. It often happens, however, that a new or different refractory can not be tried in this way because (1) insufficient brick are available for the installation, (2) it is inadvisable to chance the shutdown of a large furnace due to refractory failures, or (3) the time required to obtain the information is excessive. Therefore, it is often necessary to simulate in the laboratory conditions equivalent to those in service, but with increased severity to reduce the time required to affect the brick.

The increased severity is produced in a number of ways. The simplest is to increase the temperature above that in service. The reaction rates may increase tenfold for only a 20 to 30°C increase in temperature which enables the test to be greatly shortened in this way. Then the load or the rate of temperature change can be increased to accelerate load and spalling failures. The laboratory test is usually one of two types, (1) in which the separate properties are evaluated, and (2) in which service conditions are simulated on a small scale.

Considering the first case, there are certain definite properties such as specific heat, thermal conductivity, and thermal expansion which can readily be measured in the laboratory, and will generally be the same under service conditions. There are other properties depending both on time and temperature, such as softening point, slag resistance, load resistance, and spalling.

The softening point is only of indirect value, for this condition is seldom reached in service, but the determination serves to discard any refractory softening at or below the maximum service temperature.

The action of slag is difficult to reproduce satisfactorily in an accelerated laboratory test because action in the furnace is usually slow and progressive, and can only be accelerated by raising the temperature or by increasing the rate of slag flow. The rate of slag action bears no simple relation to the temperature, for as soon as a temperature is reached for the softening point of the eutectic between the slag and refractory, the action increases rapidly. For this reason, the resistance of a series of brick tested in the laboratory at a high temperature will not necessarily bear a relation to their resistance to slag in service at a lower temperature. The acceleration of the slag test by increasing the rate of slag flow is more logical, but entails some difficulties.

The load resistance can be accurately predicted from laboratory tests provided the temperature of the brick in service is known. In some cases failure is due to instability of the wall or arch rather than to direct load

failure. In the case of piers and rails heated uniformly, the laboratory results can be directly applied. Highly insulated walls also approach this condition.

In the same way, shrinkage tests where the brick is uniformly heated do not always apply to walls heated on one side.

The laboratory test for spalling takes many forms, but in general it attempts to give the brick a severe thermal shock. Tests on individual brick give a rough relative value of their resistance to spalling, but often a particular brick will fail to agree with service results. Spalling tests made with walls rather than brick give better results. Spalling in service is often due to surface vitrification from long heating and penetration of slag. Expansion stresses and mechanical shocks also produce cracking in furnace walls. None of these factors can be taken care of satisfactorily in the laboratory.

One of the most serious difficulties to be overcome in developing a satisfactory laboratory test is to obtain sufficient service data on a number of refractories to effect good correlation.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

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## X. Control of Firing Operations in the Manufacture of Clay Fire Brick*

BY W. E. RICE

The strength and durability of brick largely depend upon the character and degree of the firing to which they have been subjected; therefore careful control of this step in their manufacture is important. The objective of control of the firing operation is to produce economically a high yield of good brick from the clay that has passed through the earlier steps of preparation and manufacture.

In a wide sense, control of the firing operation includes the following methods:

(1) Selection of fuel to be burned in kilns.
(2) Design of kiln, particularly with regard to providing enough draft for satisfactory operation at all times, and furnaces of correct design for the fuel that is to be burned.
(3) Manner of setting green ware in the kiln so that all pieces will receive correct heat treatment, and elimination from the setting of all pieces imperfect in manufacture or not ready for firing because they have not been thoroughly dried.
(4) The actual operation of kilns by firemen in conformance to a prearranged schedule of conditions.

The present discussion is limited to the last phase, *i.e.*, the creation and maintenance of a desired sequence of conditions in a properly designed kiln which contains ware properly prepared for the process of firing. The factors to be controlled are the temperature and composition of the gas that enters the kiln. These are functions of the rate of burning of the fuel and the relation of the amount of air admitted to the amount of fuel burned, which are controlled by adjustments at the furnaces and damper.

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The draft created by a stack, stacks, or fan, is the force that draws the air that is necessary to burn the fuel through the fuel bed, moves through the furnaces and setting the mixture of hot gases which heats the ware, carries away moisture, and oxidizes carbon and sulphur in the clay. Dampers are provided whereby the intensity of this force can be regulated.

An additional means of regulation is at the furnaces where a resistance is created by the fuel bed, doors, or other means (dampers where gas or oil is burned), by which the amount of air that can enter can be regulated. Usually the resistance at the furnaces is divided; *e.g.*, in furnaces fired with coal the fuel bed constitutes one part of the resistance and the opening over the fuel bed constitutes the other. Decrease of the relative resistance through the fuel bed results in the passage of more of the air through the fuel bed and hence a faster rate of burning with less excess air. If forced draft is used, the primary air is supplied under pressure high enough to overcome the resistance through the fuel bed, and the secondary air is drawn through the firing openings where the quantity of it is controlled by doors. With forced draft close control is possible, but if in conjunction with it natural draft is relied upon to draw the secondary air into the furnace, caution must be exercised to see that pressure is not created in the furnace to prevent the admission of the secondary air, as this might result in excessively high temperatures or an undesired reducing atmosphere in the kiln.

The quantity of heat generated depends only upon the quantity of fuel burned; hence the rate at which heat is supplied to the kiln depends upon the rate of burning. But the rate of transfer of heat to the ware depends also upon the quantity of hot gas as fixed by the excess air and on the difference between the temperatures of the gas and the ware.

In the first stage of firing, the removal of mechanical water, it is desirable to heat the kiln slowly and to provide enough air to carry away the moisture.

After the water has been removed the kiln may be heated rapidly until the ware at the top has reached as high a temperature as is safe for the completion of oxidation of carbon and sulphur. During this period a high draft can be used to advantage to supply the excess air desired.

After the top of the setting has reached as high a temperature as is safe for oxidation, the temperature lower in the kiln is still below that necessary for rapid oxidation, and it is possible to continue to raise the temperature there without further increase of the temperature at the top, at the same time to maintain an excess of oxygen in the atmosphere.

When draw trials show that oxidation is complete as low as the top of the door, the temperature down to this level can be increased by increase of the rate of burning or by decrease of the excess air, but the excess air should not be below 100% until oxidation is complete at the bottom of the kiln.

After oxidation is complete throughout the kiln the temperature can be increased rapidly until the top reaches the maturing temperature.

After the temperature of the top has reached the maximum permissible, it is still necessary to raise the temperature at the bottom to the point of maturity. This again can be done by increasing the secondary air so that the temperature of the gas is not higher than the maturing tempera-

ture; also, because of the small quantity of heat required to bring the whole setting to maturity, and because of the time required for the heat to penetrate the ware, it is possible to begin to decrease the rate of burning of the fuel and thus to effect a saving.

Finally, after all the ware has reached the maturing temperature, that temperature must be maintained for a certain period of time to complete the necessary heat treatment. This soaking does not require that additional heat be delivered to the ware, and therefore it is only necessary to burn enough fuel to compensate for the heat that is lost by conduction. If a reducing atmosphere is desired to develop color, the fuel bed should be thick and the opening above the fuel bed should be closed tightly so that not enough air is admitted to burn all the combustible gases produced in the fuel bed.

For close control and economical operation, heat should be applied at constant rates. A uniform heat is easily accomplished when the fuel is thus supplied, as is the case with oil and gas, but it is not so easy to obtain with solid fuels; often bad practice in this respect is the cause of unsatisfactory results in kilns fired with coal.

In periodic kilns the gas from each furnace rises to the crown of the kiln and there mixes with gas from the other furnaces before it comes in contact with the ware. This permits a closer approach to constant conditions in the kiln by the firing of alternate furnaces, so that when the furnaces fired at each firing are delivering gas of low excess air and high temperature, the adjacent furnaces on each side are delivering gas of higher excess air and lower temperature. Thus the heat is transferred to the ware at a more uniform rate and there is less likelihood of reducing action of the mixture of gas. The method of firing alternate furnaces is applicable with advantage except when it is desirable to create a reducing atmosphere in the kiln; then all the furnaces should be fired at the same time and the firing openings tightly closed so that nearly all the air will be drawn through the fuel bed.

The foregoing discussion shows that in a typical firing cycle the rate of burning fuel is progressively increased and the excess air decreased.

When draft gages are used it is the common practice to connect them so that they measure the static pressure in the main flue between the kiln and the damper as compared to atmospheric pressure. The readings they give are not direct measures of the quantity of gas passing through the kiln, but are compounded from the quantity of gas, the temperature of the gas, and the resistance to flow up to the point where the draft tube is inserted, including the resistance of the fuel bed. The most direct use of gages so connected is that the change in reading can be used as a guide when the damper in the flue is moved.

The use of pyrometers in kilns has received more attention than that of other instruments. Pyrometers do not entirely replace pyrometric cones, shrinkage disks, or other devices used to measure the overall heat treatment, but the particular value of pyrometers is that they are a guide to the heating below the temperature at which these devices become effective.

Although analyses of flue gas are of great value as aids to the establishment and maintenance of good practice in the burning of fuel in kilns, yet at present they are little used. Combustion in kilns is usually com-

plete; therefore, if the analysis of the fuel is known, a curve can be plotted from which the percentage of excess air or the ratio of air to fuel used can be read directly from a determined percentage of carbon dioxide in the flue gas. If combustion is not complete, as during flashing, it is necessary to determine also the carbon monoxide to obtain an approximation of the ratio of air to fuel.

PITTSBURGH EXPERIMENT STATION
U. S. BUREAU OF MINES
PITTSBURGH, PA.

## XI. Control Testing of Fired Brick from the Viewpoint of the American Society for Testing Materials Methods

BY L. J. TROSTEL

One of the objects of the American Society for Testing Materials is to standardize test methods. The Society is organized into committees appointed to study the properties of special groups of materials and Committee C8 has jurisdiction over refractory materials.

### (1) General Types of Tests

Reference to the specific tests of interest in this Symposium should be prefaced by a brief classification of the tests used on fired brick in order to understand properly their relation toward the problem of controlling the properties of the brick.

In general, there are three types of tests in use based on their objectives, *e.g.*, control, simulative service, and actual service tests.

The term "control test" would seem to be more properly limited to tests of a single property of a refractory and the manner of conducting the test does not necessarily need to compare with a condition of usage. The thermal expansion, for instance, may be determined accurately upon small fragments, instead of building a furnace wall of the brick, heating it to service temperatures, and measuring the expansion with a rule.

The term, "simulative test," should be applied to those tests made in the laboratory which are intended to be a short cut to the actual service test. The latter test involves all of the variables present in the particular melting or heating furnace in which the test is conducted.

### (2) A.S.T.M. Tests

The following tests have been approved as standard by Committee C8, A.S.T.M.

(*a*) P.C.E. for fire clay and silica products (C24–31)[13]
(*b*) Chemical analysis of fire clay and chrome (C18–21)[14]
(*c*) Volume change and porosity for all refractories (C20–20)[15]
(*d*) Load for fire clay and silica brick (C16–20)[16]
(*e*) Determination of modulus of rupture (C67–31)[17]

A sixth test, water-dip spalling test for fireclay refractories (C38–31T),[18] has been approved as a tentative standard.

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[13] A.S.T.M. Standards, *Supplement*, p. 69 (1931).
[14] A.S.T.M. Standards, Part II, Non-Metallic Materials, p. 213 (1930).
[15] *Ibid.*, p. 207.
[16] *Ibid.*, p. 202.
[17] A.S.T.M. Standards, *Supplement*, p. 65 (1931).
[18] *Proc. A.S.T.M.*, 31 [1], 779 (1931); Tentative Standards (1931). Price 28 cents.

The so-called reheat test has never been approved either as a standard or tentative standard but its use in all of the specifications of Committee C8 has given it the authority of a standard.

The Committee had a tentative standard slag test, but this was withdrawn in 1925.

Investigations for several years have been sponsored by the Committee on a hot abrasion test, but none has yet yielded results which might be used as a basis of a standard test.

Strictly speaking, only those tests which detect differences in properties produced by the firing treatment can properly be considered as suitable for control of quality of fired brick.

In spite of the fact that the P.C.E. is largely an inherent property of the material little affected by the firing treatment, and likewise the chemical composition, since the only change chemically during firing is the loss of water of crystallization and the oxidation of a few minerals and organic compounds, nevertheless both the P.C.E. test and chemical analysis prove valuable for use in determining uniformity of composition of the raw materials.

The load, spalling, and reheat tests are most likely to detect differences in brick due to the firing treatment and therefore may be used for control purposes. All three tests are empirical and attempt to simulate service conditions.

The load test determines when the bond fails under the combined effect of heat and load. It furnishes two types of data: (*a*) the temperature of failure evidenced either as gradual softening or sudden shear, and (*b*) the total percentage of permanent shrinkage due to the compression. The properties of the brick which produce these effects are grind, process of manufacture, and firing. Therefore the test may be used by the consumer as a hot strength test and by the maker as a control of the proper degree of firing to produce maximum hot strength.

The present water-dip spalling test is essentially a determination of the effect of thermal shock only. Mechanical pinching set up by thermal changes such as the rising of a heated arch, or structural spalling caused by vitrification of the fire face while due to heat are not due to thermal shock if this is interpreted to mean sudden heat changes. It is generally understood that open-textured, light-fired brick do not spall in this particular type of test as readily as very dense, high-fired brick. This simply means that grind and firing affect dilatation, plastic flow, and elasticity. Since there are no good tests for these individual properties, the water-dip test must be used to obtain an expression of the composite effect of all the properties involved.

A spalling test is now under observation which is hoped to yield results that can be shown to be the resultant of the factors involved in thermal shock plus vitrification at the fire face.

The reheat test is designed to determine the volume-stability of a brick free from superimposed load at a temperature generally higher than that at which it was fired and close to that at which it will be used. The data furnished are per cent linear change at 1400°C. The results obtained are in general due to the uncompleted or new mineral reactions resulting from the higher temperature of the test which is somewhat in excess of the usual firing treatments of most fireclay brick.

The results of the test are apt to be contradictory on the same brand when tested in different laboratories.

This after- or residual-shrinkage is dependent on the kind of clay used, the grind, and the first firing treatment given the brick.

The consumer may use the test as one indicating the amount of after-shrinkage, but as pointed out he must be careful not to interpret expansion as overfiring due to the development of vesicular structure. To the producer the test will always be a valuable guide to control the temperature and duration of firing various clays.

It may be questioned as to why the last three A.S.T.M. tests are empirical and simulative. This is due to the fact that a more scientific knowledge of the reactions of clays under the influence of heat and other agencies has not been developed. The present tests should accordingly be considered stop-gaps and their perfection or gradual evolution to a more scientific type will come as more fundamental conceptions are developed.

General Refractories Company
Baltimore, Md.

# ACTIVITIES OF THE SOCIETY

## EXHIBITS OF AMERICAN CERAMICS

In the executive offices of the AMERICAN CERAMIC SOCIETY is an exhibit of ceramic ware which has been proclaimed to be very valuable. It is growing. If your ware is not represented you alone are to blame.

Aside from several historical plates contributed from private collections, there have been six recent contributions from ceramic companies.

**Corning Glass Works** The Corning Glass Works has placed on permanent exhibition the following pieces of ware: insulators, Pyrex washing machine tub, fuse plugs, ampoules, utility dish, oval casserole, nursing bottle, custard dishes, pie plate, Pyrex upset piping.

**Robertson Art Tile Company** D. Parry Forst, Trustee Representative of the White Wares Division, has contributed a Washington Memorial plaque, medallion bust of Washington on a beautiful gray-green mat glaze background.

**Bailey-Walker China Company** These manufacturers of vitrified chinaware have contributed twenty-three 7- and 10-inch plates in a white body and underglaze print, six being in commemoration of the Washington Bicentennial. There are also five plates in ivory, beautifully decorated.

**Corhart Refractories Company** This company is sending a line of cast mullite refractories for exhibit purposes.

**Corundite Refractories Company** Corundite Refractories Company has added a lightweight refractory to the exhibit. This piece is in addition to an exhibit which was contributed several years ago.

**O. Hommel Color Company** This Company has reduced the official seal of the AMERICAN CERAMIC SOCIETY to colors on enameled iron. It is framed and has an honored wall position.

If your firm wishes a permanent exhibit of products where people will see it, or if it is your desire to add to the value of this already creditable exhibit, we shall be glad to take care of your offering and thank you in advance.

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## ESKESEN AND KELSEY OFFICIAL DELEGATES OF THE SOCIETY AT INAUGURATION OF UNIVERSITY PRESIDENTS

E. V. Eskesen, past president and present Trustee of this SOCIETY represented the SOCIETY as a delegate at the inauguration of Dr. Robert Clarkson Clothier as President of Rutgers University on Saturday, June 11, at New Brunswick, N. J.

V. V. Kelsey, Trustee of the AMERICAN CERAMIC SOCIETY, was delegated to attend the inaugural exercises of Dr. William A. Boylan as President of Brooklyn College, Tuesday, June 21.

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## JOSEPH W. MELLOR, ONE OF OUR HONORARY MEMBERS

### A Scientist and Caricaturist

The following notice is taken from the *Evening Sentinel*, of Staffordshire, England, on May 21. We love the human side which, this great scientist showed us when he visited America. It is interesting to know that he is equally loved by his home folks for these same human traits.

All who take an interest in the scientific side of the pottery industry will appreciate the gesture of the AMERICAN CERAMIC SOCIETY in conferring Honorary Membership upon Dr. J. W. Mellor, F.R.S., Hon. Secretary of the Ceramic Society of this country, and principal of the Pottery Department of the North Staffordshire Technical College. Research work, in which Dr. Mellor has played so prominent a part, forms a most valuable aid to the practical potter in the maintenance of this unrivalled standard of technical perfection.

One frequently finds that men possessing shrewd, scientific minds have a lighter side

to their temperament, but it is not often they find such effective expression as in the amusing sketches by which Dr. Mellor delights to portray the humorous aspect of dignified assemblies. His pictorial commentaries on the gatherings during the Josiah Wedgwood Bicentenary celebrations are still remembered, and in the droll cartoons on

Peter Pan in trouble again — pneumonia threatening this time. They took him to a private hospital.
L'INFERNO
Naughty justice! In what store does he keep it? New pains, new torments as were here endured! Whatever fault of ours hath brought us to this? Dante.
He now wants a lot more of the same kind of trouble ... it was worth while!
IL PARADISO
...Know'st thou not thou art in heav'n And know'st not that, whatever is in heav'n Is holy, and that nothing there is done But is done zealously and well? Dante,

his recent illness he showed once more that, like a true caricaturist, he does not spare even his own misadventures when they offer a promising subject.

Dr. Mellor jokes at his own expense. During the china trade safeguarding inquiry an official of the British Pottery Manufacturers' Federation asked him to come at once to a meeting in order to decide a technical problem which had arisen. "All right," replied Dr. Mellor, "as soon as I have read 'Pip, Squeak, and Wilfred.'"

This story and the fact that Dr. Mellor reads Wild West adventures indicate why he is called Peter Pan. He positively refuses to grow up.

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## NEW MEMBERS RECEIVED IN MAY

PERSONAL

**Masanobu Nakatsuji,** President, Shoseikwan Crucible Mfg. Co., Ltd., Tatsumi-cho, Higashinari-ku, Osaka, Japan.
**Edgar D. Tillyer,** Research Division, American Optical Co., Southbridge, Mass.

STUDENT

**Cyril Bradwell,** Ohio State University, Columbus, Ohio.
**Carl Victor Gezelius,** University of Washington, Seattle, Wash.
**Charles Aaron Howell,** Iowa State College, Ames, Iowa.

### Membership Workers' Record

*Personal:* Office, 2. *Student:* D. A. Moulton, 1, A. S. Watts, 1, Hewitt Wilson, 1. Total 5.

## ROSTER CHANGES FOR APRIL AND MAY

PERSONAL*

**Boyd, Robert C.,** Standard Sanitary Mfg. Co., Louisville Works, Louisville, Ky. (2801 Preble Ave., Pittsburgh, Pa.)

**Breskow, Samuel,** 5912 Douglas St., Pittsburgh, Pa. (O. Hommel Co., 3744½ Pine Grove Ave., Chicago, Ill.)

**Callinan, J. Gavin,** Sheet Glass, Ltd., Queensborough, Kent, England. (Box 933, Clarksburg, W. Va.)

**Cook, W. H.,** 131 East Sixth St., Burbank, Calif. (628 S. Griffin Ave., Los Angeles, Calif.)

**Gautsch, Murray C.,** Baltimore Enamel & Novelty Co., Baltimore, Md. (641 Magie Ave., Elizabeth, N. J.)

**Gregorious, J. S.,** Pittsburgh Plate Glass Co., Window Glass Research Dept., Creighton, Pa. (Mt. Vernon, Ohio.)

**Hull, Walter A.,** 1284 East Third St., Salem, Ohio. (227 Clinton Ave., Oak Park, Ill.)

**Kautz, Karl M.,** 259 Twelfth Ave., Columbus, Ohio. (101 N. Ohio Ave., Abingdon, Ill.)

**Malsch, Werner,** 402 Sixth Ave., Belmar, N. J. (534 Hudson St., Hoboken, N. J.)

**Rhode, Irma,** Berlinerstr. 66, Charlottenburg, Germany. (Parkview Hotel, St. Louis, Mo.)

**Russ, John T.,** 902 Military Rd., Niagara Falls, N. Y. (1899 Waldeck Ave., Columbus, Ohio.)

**Schaefer, Earl F.,** 1224 Clawson St., Alton, Ill. (342 Berkley Rd., Indianapolis, Ind.)

**Schweickhardt, W. K.,** 730 Berkley Rd., Indianapolis, Ind. (3249 Lafayette Ave., St. Louis, Mo.)

**Seabright, Edward C.,** Ferro Enamel Corp., 4150 East 56th St., Cleveland, Ohio. (249 Seventh St., Martins Ferry, Ohio.)

**Shepherd, John F.,** 5834 Ridge, Cincinnati, Ohio. (2021 Hudson Ave., Norwood, Ohio.)

**Shoemaker, George W.,** Ar-Ke-Tex Corp., Brazil, Ind. (17 N. Meridan St., Indianapolis, Ind.)

**Sweely, B. T.,** Chicago Vitreous Enamel Product Co., 1407 S. 55th Court, Cicero, Ill. (Baltimore Enamel and Novelty Co., Baltimore, Md.)

**Taylor, Royal W.,** 642 Maryland Ave. S.W., Canton, Ohio. (221 N. Sixth St., Coshocton, Ohio.)

**Trevathan, P. Edward,** 733 Peachtree St., Rocky Mount, N. C. (Harbison-Walker Refractories Co., Templeton, Pa.)

**Watson, Donald J.,** Watson Coal Co., Sioux City, Iowa. (173 Rector St., Perth Amboy, N. J.)

**Watson, William A.,** 2328 Union Guardian Bldg., Detroit, Mich. (1159 Leader Bldg., Cleveland, Ohio.)

**Wilson, Charles L.,** Davis Hotel, Brazil, Ind. (4927 Wesley Ave., Norwood, Ohio.)

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## LOCAL SECTION NEWS

### Baltimore-Washington Section

The members of the Baltimore-Washington Section of the AMERICAN CERAMIC SOCIETY held a spring meeting at the Emerson Hotel in Baltimore on the evening of May 21, 1932. E. B. Matthews, Chairman of the Geology Department, Johns Hopkins University, and State Geologist of Maryland was the speaker of the evening. His subject was "Geology of the Raw Materials Used in the Ceramic Industries." Members of the Section exhibited specimens of Maryland raw materials and discussed interesting deposits.

Election of officers was held at this meeting.

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* Addresses within the parentheses ( ) represent the old addresses.

These Roster changes which are published each month may be checked against the complete Membership Roster which appeared in the July, 1929, issue of the *Bulletin*. Copies of this issue may be obtained from the Secretary's office, price $2.00.

## OFFICIAL PERSONNEL OF DIVISIONS, 1932–1933*

| | Art | Enamel | Glass | Materials and Equipment | Refractories | Structural Clay Products | Terra Cotta | White Wares |
|---|---|---|---|---|---|---|---|---|
| *Trustee* | C. L. Sebring | W. C. Lindemann | F. C. Flint | V. V. Kelsey | J. M. McKinley | H. C. Kleymeyer | D. F. Albery | D. P. Forst |
| *Chairman* | Walter Suter | W. V. Knowles | E. W. Tillotson | H. F. Kleinfeldt | S. M. Phelps | A. P. Potts | R. F. Grady, Jr. | H. M. Kraner |
| *Vice-Chairman* | | | H. H. Blau | L. A. Vincent | R. A. Heindl | H. R. Straight | R. L. Clare | |
| *Secretary* | K. E. Smith | W. N. Harrison | J. H. Waggoner | V. V. Kelsey | H. E. White | M. W. Blair | D. J. Watson | Louis Navias |
| *Research* | A. E. Baggs<br>Paul Bogatay | R. R. Danielson<br>B. T. Sweely<br>M. E. Manson | G. W. Morey | C. C. Treischel<br>F. P. Knight, Jr. | D. W. Ross | R. K. Hursh | Harry Spurrier | Louis Navias |
| *Standards* | | | | | | | | |
| (a) *Tests* | Guy Cowan | C. J. Kinzie | W. C. Taylor | W. J. Watkins | S. M. Swain | A. V. Henry | A. L. Bennett | A. S. Watts |
| (b) *Products* | | | James Bailey | B. C. Burgess | C. E. Bales | H. R. Straight | P. W. Lee | |
| *Membership* | C. M. Harder | J. E. Hansen | R. R. Shively | C. H. Pedrick, Jr. | S. S. Cole | E. E. Krauss | T. O. Smith | C. C. Treischel |
| *Data* | E. deF. Curtis | H. D. Carter | S. R. Scholes | R. B. Ladoo | R. E. Birch | G. H. Duncombe | H. D. Callahan | C. W. Parmelee |
| *Education* | A. E. Baggs | A. I. Andrews | E. L. Hettinger | C. W. Parmelee | M. E. Holmes | J. W. Whittemore | A. E. Baggs<br>J. L. Carruthers | W. K. McAfee |
| *Papers and Program* | C. M. Harder | R. M. King | H. H. Blau | G. H. Brown | R. B. Sosman | J. O. Everhart | S. J. McDowell | R. F. Geller |
| *Rules* | F. H. Rhead | R. D. Landrum | F. C. Flint | R. B. Carothers | D. W. Ross | A. F. Greaves-Walker | H. E. Davis | L. E. Barringer |
| *Exhibition* | M. M. French | | | | R. F. Ferguson | | H. G. Schurecht | George Simcoe |
| *Nominations* | Theo. Lenchner<br>P. E. Cox | B. T. Sweely<br>B. A. Rice | G. W. Morey<br>J. T. Littleton | F. P. Nickerson<br>F. G. Lord | A. E. R. Westman<br>E. H. Van Schoick | John D. Martin<br>C. E. Nicely<br>J. E. Randall | O. E. Mathiasen<br>W. J. Stephani | P. D. Helser<br>Robert Twells |
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| *Advisor* | Richard Bach | | | | | | | |

* For Standing Committees see *Bull. Amer. Ceram. Soc.*, **11** [5], 125 (1932). Correction: Robert Twells, *Chairman of Research.*

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*Awards:* Perry D. Helser, *Chairman.*
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## NECROLOGY

### Fred M. Locke

Fred M. Locke, inventor of the porcelain insulator, died suddenly at his home in Victor, N. Y., April 15, 1930. The death on March 5, 1930, of his son and co-worker, Fred J. Locke, was a severe strain upon him and undoubtedly hastened his death.

Mr. Locke was born in West Mendon in the town of Honeoye Falls, April 24, 1861. After attending the common schools, he became a telegrapher and followed that occupation from 1880 to 1887. He became interested in electricity and while operator and agent at the New York Central Railroad Station in Victor he spent much of his spare time in experiments. Having noticed the breaking down of insulators during storms he sought a form and material that would not allow the leakage caused by moisture, and succeeded in producing a porcelain that had the desired qualities. His first experiments were made in his kitchen.

F. M. Locke

He constructed a kiln in which to fire the porcelain and in 1898 began the manufacture of the Locke porcelain insulators at Victor.

The business was incorporated in 1902 and now, under the name of the Locke Insulator Corporation, operates large plants in Victor and Baltimore. In 1904 Mr. Locke retired from active business but continued to carry on experiments in a large laboratory in his home.

Mr. Locke had been associated with the American Ceramic Society since 1906 and his company has carried a corporation membership since 1924.

This is a brief sketch of the accomplishments of a boy of common "three-R's" education; born in 1861, a telegraph operator from the age of 19 to 27; realized the necessity for and discovered the composition, the tools, and the process of high-tension porcelain insulators; began their manufacture in 1898 at the age of 37, and sold the business to a corporation in 1902 at the age of 41.

Thus, a boy, without formal schooling, without knowledge or experience in pottery making, and with no precedent, in the short span of 41 years created a new product and developed it to meet an exacting heavy duty, and had retired. What a lesson and an inspiration!

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# NOTES AND NEWS

## THE CANADIAN CERAMIC SOCIETY JOURNAL

Volume 1, Number 1 is issued; a brave venture under the present world-depressed circumstances, but an exceedingly creditable one.

Twelve articles comprising 64 pages well edited and printed. It is an auspicious as well as an ambitious start.

## MAJOR E. HOLMES ACCEPTS APPOINTMENT AS DEAN OF CERAMIC DEPARTMENT AT ALFRED UNIVERSITY

Major E. Holmes, head of the Department of Ceramic Engineering of the School of Mines and Metallurgy, and director of the Missouri Clay Testing and Research Laboratories, University of Missouri, Rolla, Mo., has been appointed Dean of the New York State College of Ceramics, Alfred University.

While this position is under the title of "Dean" instead of "Director" in accordance with the change of the name of the ceramic school from the State School of Clay Working and Ceramics to the State College of Ceramics, Dr. Holmes is really successor to Charles F. Binns, who for nearly thirty-two years has held the position of director of the school.

MAJOR E. HOLMES

Dr. Holmes is a graduate of the University of Indiana and of Cornell University. He was for some time chemical director of the National Lime Association and for a while acting general manager of the same organization. For three years he conducted a research problem at the U. S. Bureau of Mines, the Ceramic Experiment Station, at Columbus, Ohio.

In 1926 he received the appointment of director of the newly instituted course in ceramic engineering at the School of Mines and Metallurgy, Rolla, Mo. During the past six years, Dr. Holmes has been eminently successful in building up the work of this school and has succeeded in giving it a permanent and important place in the development of ceramic interests in the middle west.

His success in the Missouri school in establishing contacts with ceramic industry as well as his sympathetic understanding and knowledge of students give him an unusually favorable background for the work he is undertaking with the New York school.

Dr. Holmes has been a member of the AMERICAN CERAMIC SOCIETY since 1921 and was elected a Fellow of the SOCIETY in 1931. He has been an active worker in the SOCIETY on various committees, but his outstanding work has been in connection with research on Missouri Ceramic raw materials and contributions to the activities of Committee C8 of the A.S.T.M. He has been a frequent contributor of technical papers to the *Journal* for the past eight years. He is also a member of the American Chemical Society, the Institute of Chemical Engineers, the Sigma Xi honorary fraternity, and the Cosmos Club of Washington.

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## S. R. SCHOLES APPOINTED HEAD OF DEPARTMENT OF GLASS TECHNOLOGY AT ALFRED UNIVERSITY

The appointment of S. R. Scholes as head of the Department of Glass Technology in the New York State College of Ceramics, Alfred, N. Y., has been approved. Dr. Scholes will take up his new duties on July 1. A detailed announcement of the courses planned in this department as well as the reorganized courses in the College of Ceramics as a whole will be presented later. A biographical sketch of Dr. Scholes follows:

Born: Marquette, Green Lake Co., Wis., 1884.

Common schools and high school, Green Lake, Wis., 1890–1900.

Preparatory school, Ripon, Wis., 1900–1901.

Ripon College, B.A., 1905; mathematics-chemistry as majors; Fellow in Mathematics, 1904–1905; editor, college paper; president, senior class; "R" in football and track; college hammer throw record, 1905.

Apprentice in family wagon shop between terms; learned carriage-blacksmith trade.

Instructor in physics and chemistry, Wausau (Wis.) high school, 1905–1908, and athletic coach.

Graduate student, University of Chicago, summer, 1907.

Graduate School, Yale University, 1908–1911; instructor in chemical laboratory, Sheffield Scientific School, 1908–1910; Loomis Fellow in Chemistry (by competitive examination) 1910–1911.

Ph.D., Yale University, 1911; Thesis, "Vapor Pressures of Crystalline Hydrates."

S. R. SCHOLES

Appointed to H. C. Fry Glass Co. Fellowship at University of Pittsburgh under R. K. Duncan, 1911. Developed lined glass pot for heavy potash-crystal glass. Experimented on electrical glassmelting and on various glass compositions. Became chemist for H. C. Fry Glass Co. at end of fellowship term, 1913, and remained associated with this company until 1920.

Meanwhile, the Industrial Research Laboratory at the University of Pittsburgh became Mellon Institute. Appointed assistant director, 1914. In 1917, left Mellon Institute to give full time to Fry plant. Made heavy lead crystal without potash, and with saltpeter instead of carbonate of potash; laboratory glassware, oven glass, lamp-working tubing for government laboratories, combustion, and gage-glass tubing.

Went to Lonaconing, Md., 1920, to operate factory to make headlight lenses. Lost this job in 1921 depression. Obtained job as chemist, Federal Glass Co., Columbus, Ohio, 1921, remaining until 1929 working on annealing problems, large-scale production of crystal glass for automatic and hand production, tank design and operation, special items for automatic manufacture, green glass for tumblers and tableware, and general control of raw materials and standardization.

During this period published several articles on tanks and tank blocks, worked out set of factors for density calculation, gave several series of lectures on glass at Ohio State University, department of ceramic engineering, and advised on thesis work there.

While at the University of Pittsburgh and Mellon Institute filled teaching assignments in general and industrial chemistry and fuels. Lectured in chemistry at Geneva College, Beaver Falls, Pa., during the War.

1918 invented (with Nicols and Kaufman) a revolving pot for mixing optical glass; not yet a commercial success.

1929 went to Fostoria Glass Co., Moundsville, W. Va., as Technical Director. Worked on colors and improvement of crystal glass (pot) for dinnerware. Made "Wistaria" glass economically with neodymium oxide; released 1931.

Engaged by Federal Glass Co. for color work, 1931. Made an economical yellow and also a blue for tableware.

Has flair for writing verse; author (1926) "The Community Church Hymn," now in use by a number of community churches; wrote other hymns.

Member of Masonic fraternity, Acacia (V.D. Yale Chapter, 1910), Alpha Chi Sigma; elected to Sigma Xi, 1911.

Served as Chairman of the Glass Division, AMERICAN CERAMIC SOCIETY in 1920 and also on several committees; was elected Fellow of the AMERICAN CERAMIC SOCIETY, 1931.

In the American Chemical Society, Chairman of Pittsburgh Section, 1918; Councillor, 1919–1920; established *The Crucible*, bulletin of the Pittsburgh Section, 1918.

In public service, member of Board of Education, Grandview Heights, Ohio, for six years; "Veteran Scouter," having served as Scoutmaster, Committeeman, or Local Council member for eight years or more; active in South Side Industrial Y.M.C.A., Columbus, Ohio.

Married Lois Elizabeth Boren, Pittsburgh, 1914; three sons, one daughter.

Admits playing fair golf and good bridge.

Subjects of researches and published articles include the following: Iodine derivatives of toluidine; nature of precipitated colloids; HF-$H_2SO_4$ decomposition of feldspar; vapor pressures and drying agents; arsenic in glass; laboratory glass furnaces; description of the American table glassware industry; behavior of manganese in glass; tank block corrosion; furnace temperature measurement; potash from feldspar (patent); analytical methods for glass and glassmaking materials; natural gas and producer gas as glass-furnace fuels; "How Fostoria Glassware Is Made"; density factors for soda-lime glasses; also a number of articles on glass in popular style for trade journals.

## LAMME MEDAL AWARDED TO ALBERT V. BLEININGER BY OHIO STATE UNIVERSITY

The second annual award of the Lamme medals, established by the late Benjamin G. Lamme, '88, Ohio State University, for "meritorious achievements in engineering of the technical arts," was a feature of the Fifty-fifth Commencement of the University on June 13, 1932. This year's recipients were Albert V. Bleininger, Newell, W. Va., ceramic chemist, and Ralph D. Mershon, New York City, consulting electrical engineer and inventor.

When Mr. Lamme died in 1924, he left $6000 to endow the medals to be given annually. They were awarded last year for the first time, those honored being C. E. Skinner, Pittsburgh, assistant director of engineering, Westinghouse Electric & Mfg. Co., and Arno C. Fieldner, Washington, D. C., chief engineer, Experiment Station Divisions, U. S. Bureau of Mines.

Following his graduation here in 1901, Bleininger was a member of the ceramics faculty for six years and then went to the University of Illinois. In 1908 he became chief of the clay products section of the U. S. Geological Survey, returning to the University of Illinois from 1910–1912. For the next eight years he was in charge of the ceramic division of the Bureau of Standards at Pittsburgh. Since 1920 he has been chief chemist for the Homer Laughlin China Co.

During the war he was a consultant for the army's chemical warfare service. He has also served as chairman of the National Research Council sub-committee on ceramic chemistry and chairman of the U. S. Potters' Association research committee. He is a former president of the AMERICAN CERAMIC SOCIETY, and has written extensively in this field.

The Lamme medal is of gold, about $2^1/_2$ inches in diameter and is valued at $200. It was executed by Erwin F. Frey, of the fine arts department. Besides the medal, Mr. Lamme also endowed two scholarships given annually to the best junior in the department of mechanical engineering and the best in the department of electrical engineering.

The recipients were chosen by a faculty committee of the College of Engineering.

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## PROGRESS REPORT OF NATIONAL CONFERENCE ON CONSTRUCTION COMMITTEES

Here is an enterprise which should interest every ceramic technologist engaged in the production of construction materials. Constructional uses and opportunities concern technical men as well as trade associations. The committee report follows:

A general meeting of the Conference Assembly will be called in October, 1932, to consider reports and recommendations prepared by the five fact-finding committees. Members of the Executive Committee held a meeting late in June.

**Committee No. 1. Business Reports, Statistical, and Trade Information** — To examine methods of improving the statistical and trade information of value to the construction industries.

*Chairman:* S. L. Andrews, Chief Statistician, Amer. Tel. & Tel. Co., New York City.

*Members:* H. A. Babcock, C. E. Baldwin, H. F. Cellarius, Willard Chevalier, W. C. Clark, Hiram Cody, T. L. Condron, H. W. Green, T. S. Holden, R. B. Mayer, F. T. Miller, A. D. Morehouse, C. F. Palmer, J. A. Pugh, C. S. Smith, K. K. Stowell, J. Suelzer, Jr., J. S. Taylor, W. S. Tower, and L. C. Wason.

The Committee reports include a general statement on principles of statistics as applied to construction, reports on the Construction Census and Construction Employment Statistics, as well as a comprehensive statement on the subject of Local Construction Inventories to which is appended a Manual on Vacancy Surveys.

The report on Local Construction Inventories deals with local information which will be of assistance in determining the demand for various types of construction, particularly residential building. It is an important part of a contribution that this

Conference makes on the subject of planning as applied to the construction industry. It is encouraging to find that a committee composed of such diverse groups as bankers, realtors, contractors, materials dealers, and architects was able to arrive at an agreement on this important subject.

**Committee No. 2. Elimination of Wastes and Undesirable Practices** To prepare an inquiry which will identify wastes and undesirable practices as well as proposals looking to their elimination.

*Chairman:* John W. Harris, Hegeman-Harris Co., Inc., New York City.

*Members:* W. P. Christie, L. R. Crandall, Richard Deming, H. D. Dewell, A. P. Greensfelder, A. C. Holden, W. G. Luce, W. N. Mayhew, Rudolph Miller, A. T. North, Eben Rodgers, W. S. Schmidt, L. P. Sutton, Sanford E. Thompson, C. P. Winslow, and B. H. Witherspoon.

A few selected problems concerning inspection, standardization, construction management, and accident prevention are being looked into by sub-committees. The subject of planning is receiving attention and some features of planning of construction, with particular reference to present conditions, are under consideration.

**Committee No. 3. Realty Finance** To consider vital subjects related to realty finance, including appraisal methods.

*Chairman:* Louis K. Boysen, Vice-President, First Union Trust & Savings Bank, Chicago, Ill.

*Members:* D. E. Bridgman, W. W. Campbell, R. T. Cragin, H. S. Cutmore, Frederick Ecker, P. W. Kniskern, C. H. Lench, H. J. Lofgren, W. N. Loucks, J. J. O'Connor, Paul Robertson, M. F. Reidy, C. C. Shepard, P. E. Stark, G. B. Walbridge, and J. A. Zangerle.

The most important activity of this Committee has consisted of arranging for applying in a practical way the principles set forth in the report on Local Construction Inventories. Financial and other groups in an important mid-western city have expressed great interest in the set-up of an agency for carrying on such an inventory of construction continuously, as a guide in determining loan and other policies with reference to construction. A member of the Conference staff has spent the past month in assisting these interests in setting up such a group and in advising on practical operations for carrying on the work. The interest of the National Conference on Construction in this survey is that it may be considered a sample survey which may be used as a model for many other cities as it proves its practicability.

The Committee has nearly completed a report on appraisals, dealing with the appraisal technique of several important groups and making recommendations looking toward an improvement in practices and the setting-up qualifications for appraisers.

**Committee No. 4. Local Organizations** To examine the structure and activities of local organizations designed to represent comprehensively the construction interests.

*Chairman:* Ernest T. Trigg, President, John Lucas & Co., Inc., Philadelphia, Pa.

*Members:* W. A. Bechtel, R. B. Bencker, S. L. Caum, S. W. Emerson, A. J. Hager, C. C. Hieatt, G. E. Hummel, Walter Klie, Atholl McBean, C. G. Norman, Frank Parker, C. H. Paul, Oscar Reum, H. R. Sandholzer, and M. M. Swarr.

Through this Committee the Conference has been in close contact with practically all of the local building congresses. It is realized that the practical application of any principles set forth in a general conference on construction can, in general, only be carried out through the local building congresses and similar groups.

A statement of recommendations relating to local organizations in the construction field has been prepared, as well as a general report on such local organizations dealing with their organization and activities.

The Committee is prepared to offer assistance to groups in any community desirous of setting up an all-inclusive construction group.

**Committee No. 5. Economic Relationships in the Construction Industry** To study the present organization of the building and construction business and the principal economic forces involved therein.

*Chairman:* Andrew M. Eken, Vice-President, Starrett Bros. & Eken, Inc., New York City.

*Members:* A. S. Bent, C. E. Chase, L. K. Comstock, F. L. Cranford, Max Dunning, S. M. Duty, J. E. Farwell, G. E. J. Pistor, M. C. Tuttle, M. M. Upson, and Charles Warner.

The Committee has had two meetings dealing with some aspects of relationships between contractors, architects, owners, etc. A report on this subject was prepared for submission to the meeting held on June 1 in New York. At this meeting subjects of pre-qualification of bidders and elimination of bid peddling were discussed.

## B. T. SWEELY JOINS STAFF OF ENAMEL COMPANY IN CHICAGO

On June 1, B. T. Sweely, formerly general manager of The Baltimore Enamel and Novelty Co., joined the technical staff of the Chicago Vitreous Enamel Product Co. Mr. Sweely has held executive positions in several well-known enterprises in addition to being the author of several papers published by the AMERICAN CERAMIC SOCIETY. He has served as chairman of the Enamel Division for one year and also a member of the Board of Trustees for three years.

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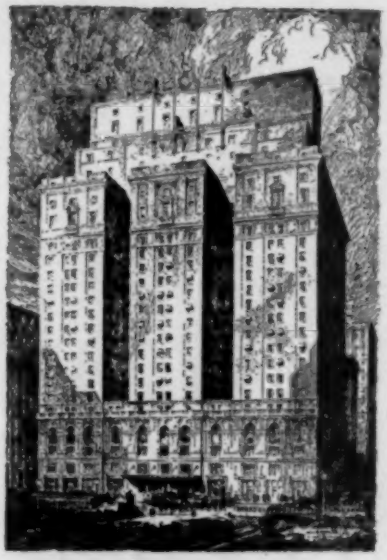

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### B

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McDanel Refractory Porcelain Co.

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**Barytes**
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Carborundum Co. (*"Carbofrax Alexite"*)

**Bitstone**
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**Blocks (Refractory)**
Carborundum Co.

**Borax**
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Drakenfeld & Co., B. F.
Hommel, O., Co.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.

**Borax Glass**
Pacific Coast Borax Co.

**Boric Acid (Anhydrous)**
Hommel, O., Co.
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Hommel, O., Co.
Pacific Coast Borax Co.
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**Brickmaking Machinery**
Hardinge Co., Inc.

**Bricks (Refractory)**
Carborundum Co. (*"Carbofrax Alexite"*)

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### C

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The Exolon Co.

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Spinks Clay Co., H. C.

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## D

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## E

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